PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS

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Affairs of the Institute

Annual Meeting Bulletin Board
Regional News
Personnel
Fellowship Awards Competition
Recently Elected Members of IFT
Books
Selected Abstracts
Food Industry Topics
Future Meetings

Annual Meeting Bulletin Board

This Is Your 1955 Annual Meeting Committee

Pictured below are seventeen people who will make your visit to Columbus, Ohio, next June a pleasant and profitable event in seventeen different ways.

First row: Inez Prudent (Women's Entertainment), George Garnatz (Co-Chairman, Program Committee), Fred Deatherage (Co-Chairman, Program Committee), H. D. Brown (General Chairman), J. B. Brown (Associate Chairman), Norbert Volle (Exhibits Chairman), M. Eloise Green (Committee Secretary).

Second row: Wilbur Gould (Publicity), O. F. Garrett (Tours), Randall G. Rice (Registration), Velt Stafford (Registration), Rees Davis (Banquet), Florren E. Long (Printing).

Third row: A. J. Glazier (Exhibits) R. C. Overbeck (Finance), C. B. Tibbits (Housing), Alden Winter (Entertainment).

(Five members of the Committee were not present when the photograph was taken. They are: Duane DeWeese, Robert Johnson, Dan McCoy, Radcliffe Robinson, and Fred Dellwo.)

Exhibit Space Going Like Hot Cakes!!!

N. H. Volle, Exhibits Chairman, and Colonel Lawrence, Executive Secretary, announce that exhibitors have responded quickly to the first announcement of exhibit space. As of this writing (October 20) all but 15 of a total of 68 spaces have been contracted for. Mr. Volle indicated that they may have to disappoint some exhibitors of long standing if they don't hurry with their contracts. Through an Exhibitors Advisory Committee made up of exhibitors every effort has been made to supply the exhibitors the best possible service and to see that all IFT members at the Convention in Columbus will view the exhibits. Arrangements are under way to make a tour of exhibit space especially interesting and profitable to IFT'ers.

Special breakfast and luncheon meetings. All requests for special breakfasts and luncheons, together with probable attendance should be sent to Mr. R. B. Davis, Banquet Chairman, Department of Horticulture, The Ohio State University, Columbus 10, Ohio before January 15, 1955. Arrangements will be scheduled in accordance with the 1955 convention program.

Open dates on the tentative program are as follows:
Luncheons—Tuesday, June 14; Thursday, June 16.
Breakfasts—June 13 to 16 (Monday through Thursday).

Mr. Norbert H. Volle, Chairman, Exhibits Committee, announces the addition of two members to the Exhibits Arrangements Committee: Mr. H. W. Putnam, Pillsbury Mills, Inc., Louisville, Kentucky and Mr. John E. Hall, Continental Can Co., Cincinnati, Ohio.

Regional Section News

CHICAGO SECTION

The United Air Lines food preparation kitchens were the rendezvous for more than 100 members of the Chicago Section at their October 7 meeting. The group was taken on an hour-long guided tour of the areas where the food is received, prepared, cooked, packaged, and placed in portable compartments for transfer to the planes.

Following the inspection, the group reassembled at the Clearing Industrial Club for a roast beef dinner. Speaker was Mr. George Nixon, Supervisor of Flight Kitchens for United Air Lines, who traced the history of United's pioneering of in-flight meals, discussed present methods in detail, then projected feeding patterns of the future when air travel speeds will be increased.

Considerable discussion followed Mr. Nixon's talk, principally concerned with customer food preferences and economics of in-flight feeding.

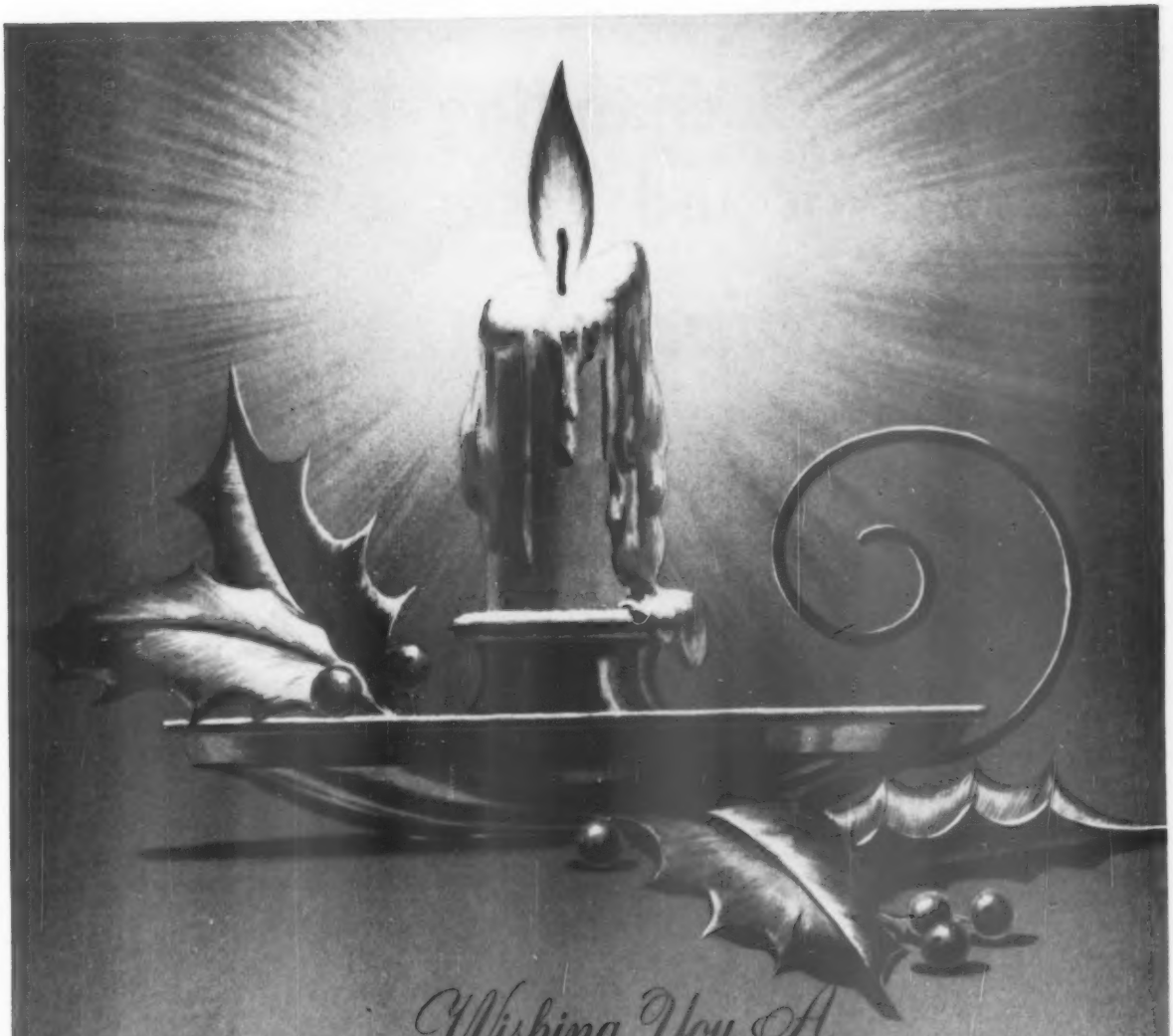
At the business meeting Chairman Brockington announced that Mr. Howard Milleville, Editor of Food Processing, had agreed to serve as Secretary for the remainder of the year, succeeeding J. L. Heid.

Program Chairman Jackson announced that at the November 8 meeting Mr. Fred Lewis of Metal Box Company will discuss "Food Packaging in Great Britain," and that at the December 13 Ladies' Night, Mr. Paul R. Leach of the duPont Company will give a popular talk, "Recent Advances."

DIXIE SECTION

On Friday, October 15, 1954 "Food Plant Sanitation" was the theme of the Dixie Section meeting. The group assembled at the ZEP Manufacturing Corporation, Atlanta, at 3:00 p.m. ZEP is one of the larger nationally known manufacturers of sanitation materials. The tour through the manufacturing plant and the talk and discussion of sanitation materials and methods by Dr. Harold B. Friedman, Director of Research, ZEP, were most rewarding. The Cherokee Room of the Cherokee Hotel, Atlanta, was the scene of the dinner session. Mr. Keith A. Fitch, Director of the Orkin

(Continued on page 5)



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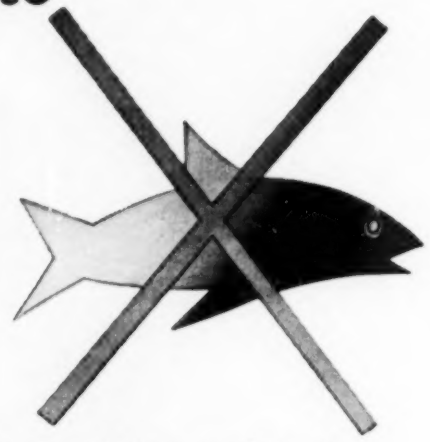

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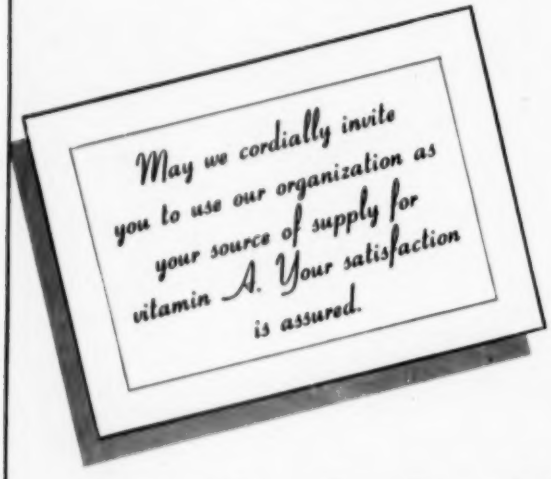

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REGIONAL SECTION NEWS

(Continued from page 2)

Institute of Industrial Sanitation, discussed "Organizing for Food Plant Sanitation" and Mr. R. O. Rentz, Chief Inspector, Atlanta Office of the U. S. Food and Drug Administration, addressed the group on "Microbiological Aspects of Food Plant Sanitation," rounding out a most pleasant "short course" in sanitation principles.

PHILADELPHIA SECTION

The Philadelphia Section met on October 5, 1954 at Drexel Institute. The chairman, Mr. Carl Pratt, made a short address, and announced the successful conclusion of arrangements which insure that the 1959 meeting of the Institute will be held in Philadelphia. The dates will be May 17 to 21, 1959.

The following committee chairmen were appointed: House committee, Keith West; Publicity committee, Dr. Walter Obold; Membership committee, Fred Jacobsen; Auditing committee, John Sampey and Fred Washington.

Reports were made by the Secretary, the Treasurer, the Membership chairman and the Program chairman. Mr. Mahle announced the program for the next two meetings, and explained the project of distributing question cards to be submitted for discussion at some future meeting.

A color film prepared by the General Electric Company, entitled "A for Atom" was shown.

The speaker, Mr. A. F. Borer, Director of the Bakery Mix Laboratories of Pillsbury Mills, spoke on the subject of "Mixes for the Baking Industry." He gave a brief history of the development of baking mixes in America and discussed the effect of changing food habits on the consumption of various cereal products. He discussed the part played by the laboratory in the development of new products, the improvement of present products, and quality control of raw materials and finished products. Production techniques in the manufacture of bakery mixes were described. A number of slides showing operations in the Pillsbury plant were shown.

After the completion of the talk, Mr. Borer answered numerous questions from the audience.

GREAT LAKES SECTION

The Section held its Fall Meeting jointly with the Ohio Valley Section at the University of Toledo, Toledo, Ohio, on October 30, 1954. Lunch was served in the University Cafeteria; there was no dinner session. The following papers were presented:

Morning Session:

"Food Plant Waste Disposal," H. D. Brown, Horticulture Department, Ohio State University.

"Flexible Packaging of Food," Florren Long, Shellmar-Betner Division, Continental Can Company.

"Margarines and Shortenings," J. B. Brown, Physiological Chemistry, Ohio State University.

Afternoon Session:

"Interpretations of Shrimp and Fish Technology," Karl Envoldsen, Envoldsen Shrimp Company.

(Continued on page 6)

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REGIONAL SECTION NEWS

(Continued from page 5)

"Sanitation Practices in Baby Food Manufacture," Hal Delo, Gerber Products Company.

"Hydrolyzed Vegetable Proteins—Their Manufacture, Characteristics and Uses," L. J. Minor, L. J. Minor Company.

WESTERN NEW YORK SECTION

The Section held its annual Fall Meeting at the Hotel Powers, Rochester, New York, on October 15, 1954. The event took the form of an afternoon and dinner session. Those known, at this writing, who presented papers included:

"Packaging Foods in Glass"—A brand-new film in sound and color. Mr. H. C. Scott, Owens-Illinois Glass Company.

"Trace Metal Problems in Foods." Mr. H. W. Zussman, Alrose Chemical Company, Providence, Rhode Island.

"The Origin and Use of Caramel Color in the Food Industry." Mr. Fred W. Peck, Sethness Products Company, Long Island City, New York.

"Food Industries in Our Area." Mr. Holt Andrews, Continental Foods Inc., Albion, New York.

Mr. William S. Conway, Jr., Richardson Corporation, Rochester, New York.

A social hour was held between 5 and 6 p.m. when beer and soft drinks were provided by the Section. Dr. David B. Hand, New York State Agricultural Experiment Station, Geneva, New York, was the dinner speaker and his topic: "Problems in Food Processing and Production on Formosa."

PERSONNEL

Dan Ridenour, past chairman of the Ohio Valley Section, was recently named to head the Product Development and Application Division of the Wm. J. Stange Co., manufacturer of food seasonings, certified food color and antioxidants. In his new position, he will be primarily concerned with the creation of new products in the food field—especially in cooperation with processors interested in product development and improvement.

Three doctorates in the field of food chemistry were granted at the University of California (Berkeley) in September. The three recipients were: Dr. Guido de Lucca, whose dissertation dealt with the formation and chemistry of aluminum pectinates, Dr. Aaron Lukton, who conducted a study of the factors affecting copper casse formation in white wine, and Dr. Paul Andrews Buck, who wrote his thesis on pyruvic carboxylase and related enzymatic activities in frozen broccoli tissues. Dr. De Lucca has returned to Sicily to take up a career in food technology there, Dr. Lukton received an appointment in Food Technology on the Berkeley campus, and Dr. Buck is now an assistant professor in the department of dairy and food industries at the University of Wisconsin at Madison.

Dr. C. O. Chichester, who received his doctorate from the University of California in June is now a member of the Food Technology faculty at the University of California at Davis.

Gerald A. Fitzgerald recently returned from two years as chief, Food Processing Branch, U. S. Opera-

(Continued on page 8)

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PERSONNEL

(Continued from page 6)

tions Mission to Iran. Formerly chief chemist, Birds-Eye Laboratories, director of the Frozen Food Foundation, and consultant to food processing industries prior to his Point IV affiliation, he plans to return to the consulting field in product research, development, and quality control. He is a Founder Member of the Institute of Food Technologists.

DR. BYRON T. SHAW, administrator of the Agricultural Research Service in the U. S. Department of Agriculture, today announced appointment of DR. GEORGE W. IRVING, JR., as deputy administrator in charge of research. In this position Dr. Irving will coordinate investigations of the 16 branches in ARS engaged in studies covering many fields of agricultural science.

General Foods Fund, Inc. Fellowship Award Open for Entries

The graduate fellowship program supported by the General Foods Fund, Inc. has been initiated, and, as announced in the November isue, the winner of the first award was Mr. Harold M. Rich, a student at the Massachusetts Institute of Technology.

Candidates for next year's award must submit their applications to the Secretary, Institute of Food Technologists, 176 West Adams St., Chicago, prior to February 1, 1955.

Applications must be in letter form and furnish the following information: Name; nationality, sex; age, marital status; physician's statement as to health; educational and experience background; college scholarship record; noteworthy research accomplishments; and the applicant's purpose in applying for the Award. Three letters of recommendation shall be forwarded, separately, to the Secretary's Office (IFT) by deans, heads of departments, and/or professors who have supervised the research work of the applicants. A statement by the head of the department where the work will be done, endorsing the applicant and accepting the responsibility connected with the Fellowship, is also required.

Further details are available in a leaflet which will be supplied on request by the Secretary of the Institute of Food Technologists, 176 West Adams Street, Chicago, Illinois.

Funds for this Award are provided by the General Foods Fund, Inc., a foundation supported by General Foods to conduct a graduate fellowship program in the field of food science; the program is administered by the Institute of Food Technologists. The fellowships are granted annually, no more than two to the same institution, but will be renewable upon application to and approval by the Awards Committee in order to provide continuity of studies toward the degree of Ph.D. if the winning candidate so plans. The General Foods Fund Inc. is financing this fellowship program by making contributions to the Institute of Food Technologists in the sum of $4000 for the Academic Year 1954-55; $8000 for 1955-56; and $12,000 for each year thereafter.

Applications for Florasynth Fellowship Award for 1955 Must Be In by February 1, 1955

The Florasynth Fellowship Award, given annually to a young man or women, under 35 years of age, who has outstanding qualities of character and personality and has demonstrated scientific or engineering ability in Food Technology in a recognized college of the U. S. A. or Canada, is now open for entries. Candidates must be seniors or graduate students to be eligible. Nomination for the award is made by the head of the department who supervises the work of the candidate. The honorarium that accompanies the Award is $500.00

The 1955 Award nominations (to be made by the head of the department who supervises the work of a candidate) must be received by the Office of the Secretary of the Institute, 176 West Adams St., Chicago, not later than February 1, 1955. After the Awards Committee has come to a decision, the name of the winning candidate will be announced at the annual meeting of the Institute of Food Technologists, June 12-16, in Columbus, Ohio.

Recipient of the 1954 Award was Mr. John E. Schade, University of California, Davis. He was nominated for the academic distinction by Dr. Emil Mrak, Chairman, Department of Food Technology, University of California.

Recently Elected Members of IFT

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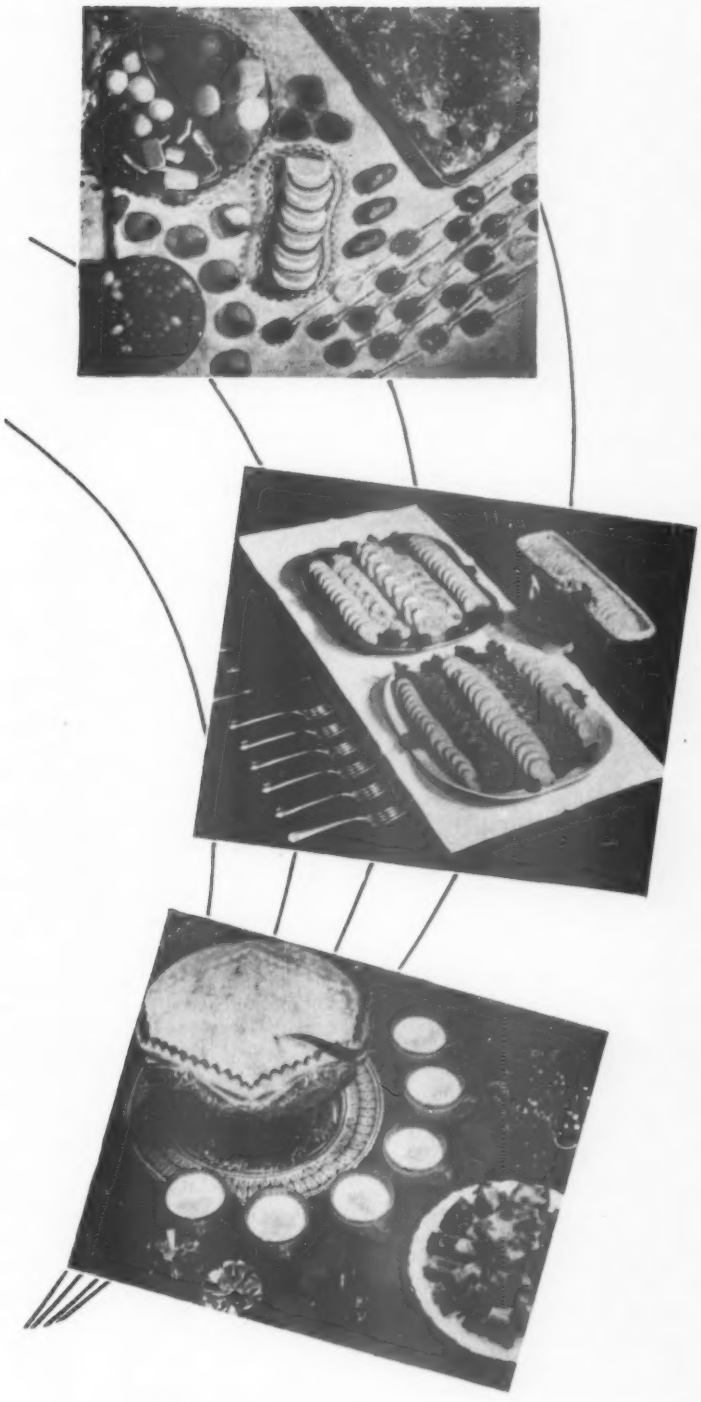

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Books

STANDARD VALUES IN NUTRITION AND METABOLISM. WADC Technical Report 52-301. Edited by Errett C. Albritton, 380 pages, xi. (Planographed) McGregor & Werner, Inc., Dayton, Ohio, 1954.

There has been a need for a modern compilation of data on nutrition and metabolism, and the present volume satisfies that need. The data which are here provided are of importance not only to research workers in the broad field of biochemistry, but to food technologists and others whose work is concerned with the chemical components of foods and feeds, and their metabolic behavior, or with the nutrient requirements of bacteria, yeasts, other organisms and the higher plants, or with the quantitative aspects of tissue respiration. The scope of the volume is the animal and plant kingdoms, including bacteria, algae and fungi.

The data are compactly arranged in 160 tables. The topics which are covered are as follows: The Nutrients, tables 1 to 9; Nutrients Utilized by Animal Forms, 19 to 26; Daily Allowances for Animal Forms, 27 to 47; Diets and Culture Media for Animal Forms, 48 to 56; Culture Media and Fertilizers for Plant Forms, 57 to 64; Nutrient and Energy Values of Foods and Feeds, 65 to 81; Nutrient Functions and Signs of Deficiency and Excess, 82 to 96; Pathways of Metabolism (charts), 97 to 111; End Products of Metabolism, 112 to 121; Oxygen Consumption, Carbon Dioxide Production of Animal Tissues and Organisms, 122 to 139; Oxygen Consumption and Carbon Dioxide Production of Plant Tissues and Organisms, 140 to 147; Energy Exchange, 148 to 160. There is a bibliography of references, which totals over 100 pages, and which is arranged so that not only can one find a reference for every figure in a table, but also so that one can identify the contributors and reviewers who are responsible for the selection of the data. Over 800 active research workers collaborated in the selection and tabulation of the data, under the editorial supervision of Professor Errett C. Albritton and his staff. The index is excellent.

This truly stupendous project was made possible by the U. S. Air Force, the Departments of the Army and the Navy, and the Atomic Energy Commission, under the supervision of a committee of the National Research Council. The present volume is distributed as Wright Air Development Center Technical Report 52-301. It is a companion volume to "Standard Values in Blood," which was issued previously as Air Force Technical Report No. 6039. The two volumes complete the project. They will be re-published as a book by W. B. Saunders and Co., Philadelphia, which will be commercially available. Students particularly will find this publication useful as a quick introduction to the data of biochemistry and nutrition.

FRANKLIN C. BING
Chicago, Illinois

YEAST TECHNOLOGY, John White. John Wiley and Sons, Incorporated, New York, 1954.

Yeast is perhaps unique in that it is at the same time the end product of a commercial manufacturing operation, a raw material in baking and brewing processes, a dietary supplement, and a basic research tool in biochemical studies. Consideration of these varied and diversified items, with major attention to the production of bakers' yeast, represents the subject matter of White's excellent book.

About two-thirds of the treatise is based on a consolidation of articles in the area of yeast manufacture and yeast physiology published previously by the author in *The Journal of The Institute of Brewing* and in *The American Brewer*. The remaining chapters are concerned with yeast genetics, nutritional applications of inactive dried yeast, production of active dried yeast, and miscellaneous physiological considerations such as osmosensitivity and irregular growth. Two contributed chapters are included—"Yeast and the Baking Industry" by A. J. Tipper and "Brewers' Yeasts" by C. Rainbow.

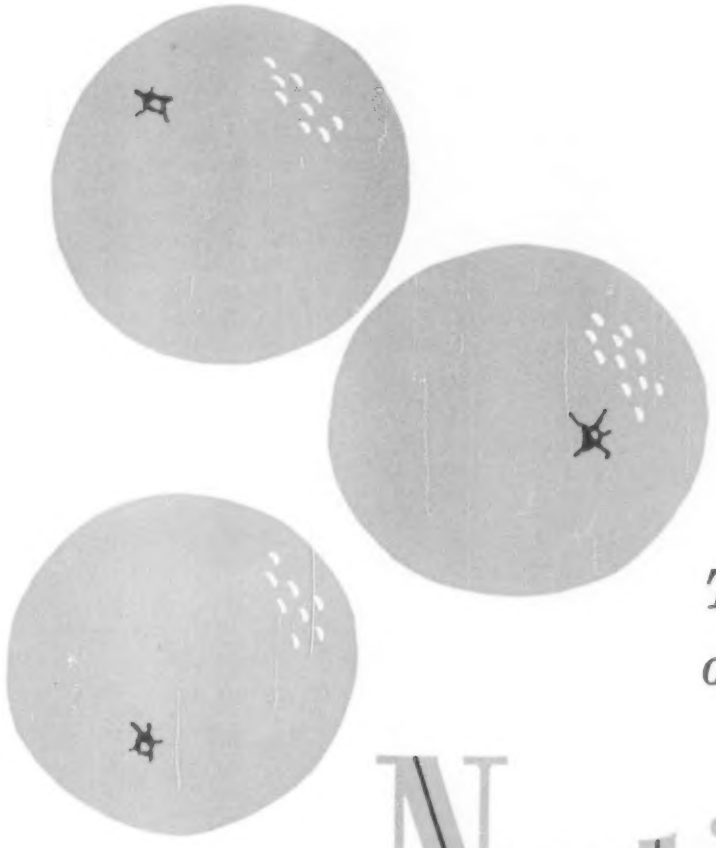
The information concerned with the manufacture and physiology of bakers' yeast is authentic and well presented. In some respects, however, the comments and opinions are probably less typical of the yeast industry in the United States than of that in Great Britain. For instance, on page 315, the author states that "the very best dried yeasts are rarely better in dough-raising power than an equal weight of normal 'wet' yeast." This opinion is hardly true of American active dry yeasts which can be used at a 40% replacement level relative to compressed yeast. The American Armed Forces have been using active dry yeast of this quality since the last war.

The excellent caliber of the material contained in the present volume leads the reviewer to suggest that the next edition might be improved by better organization and arrangement of the material. Thus, chapter 30, concerned with baking behavior of yeast, could more reasonably follow chapter 26 (dealing with the same subject) than being separated by chapters concerned with subjects such as waste effluent disposal and bactericidal effects. Similarly, information concerning temperature effects on yeast growth and fermentation might better be organized in one chapter than in two scattered ones (chapters 19 and 28). A new section concerned with methods of culture selection, purification and maintenance would perhaps be of value in rounding out the scope of the book. It might also be mentioned that a few typographical errors were found, a minor one (p. 220) being the use of Backmann for Bachman.

Mr. White's book successfully covers a large and important area and manages to give a well-balanced birds'-eye view of the various aspects of the "art" and "science" of yeast technology. Its 59 tables and 32 chapters can be expected to provide valuable reference material to the fermentation, baking and brewing technologist. It may also be recommended with confidence to the research worker in the fields of yeast metabolism and physiology for its value in directing attention to an area where basic explanations for empirical findings are scarce.

LAWRENCE ATKIN
Stamford, Connecticut

(Continued on page 12)



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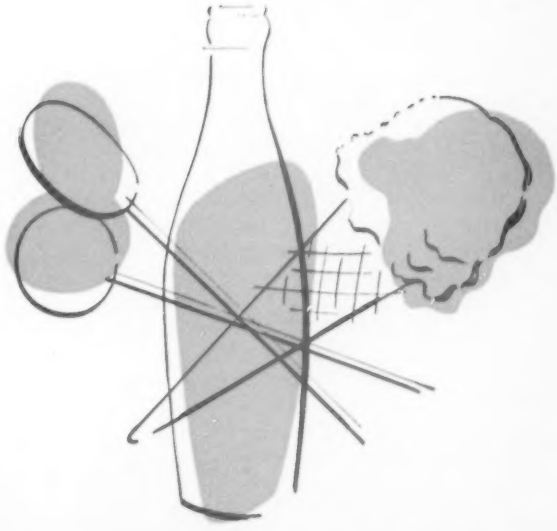

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BOOKS

(Continued from page 10)

THE TECHNICAL REPORT: ITS PREPARATION, PROCESSING, AND USE IN INDUSTRY AND GOVERNMENT. Edited by B. H. Weil. Reinhold Publishing Corporation, New York, N. Y. Price, $12.00.

The purpose of this 485-page book is stated to be the presentation of the "latest and best practices for writing, editing, duplicating, filing, retrieving, and using technical reports." Participating in this commendable quest are a score or more of technical information specialists and others. Several of the contributors were members of a symposium on the research report sponsored by the Division of Chemical Literature of the A. C. S. in September 1953, and their papers—ten in all—are the basis, but by no means the entire structure, of the volume.

As the title promises, the book treats the technical report and its role in industry and in government. Although the purposes are sometimes divergent, both industry and government use the technical report "to provide thorough dissemination of current information" and "to provide a permanent record of information obtained." Both groups are engaged heavily in two types of scientific information activity; namely, communication of the results of work in progress and the formal reporting of definitive results. To the first type the term "science in the making" has been assigned; to the second "science as an institution." The author of this distinction of types has pursued the point further and assigned to "science in the making" the symbol S_1 and to "science as an institution" the symbol S_2. In reading further one discovers that S_1 is a semantic abstraction for *progress, status, informal* or *privileged* reports; S_2 is reserved for *final, definitive, formal* or *public* reports. No doubt those frenzied, impatient souls who look on the flood of technical literature and long for a magic formula to brief it all down to a simple system of one-sentence reports will note with delight this small feat of semantic brevity. In coming upon S_1 and S_2 without context, of course, one must search for the path back to meaning; namely, back to the types of report symbolized and then back of those to the admirable, more lesiurely distinctions, "science in the making" and "science as an institution."

But it would leave entirely the wrong impression if the interlude regarding S_1 and S_2, a few paragraphs in an introductory chapter, were to be taken as keynoting the content of the book. On the contrary, *The Technical Report* is a sober, comprehensive treatment of writing, publishing, using, and distributing the report. It gets down to the details in every chapter. In writing the report one is instructed in Chapter 4, for example, in how to *analyze, investigate, design,* and *apply*—in other words how to "engineer" the report. The chapter on the mechanics of writing begins with the common faults of writing, such ancient villains as confused word order—"I wanted to grow up so I could shoot wild ducks like my father"—the misuse of "affect" for "effect," and so on.

A most valuable section of the book deals in considerable detail with the arts of illustrating, duplicating, and binding reports. In the ninety or more pages reserved for this subject, much of the "know-how" of these aspects of report publication are given. In fact, the distillation of years of experience is crammed into this brief space. Indexing and filing reports comprise another helpful section of the book. In between and within the major sections are innumerable expositions of other features of report writing—the literature search, summarizing, use of references, etc.

The Technical Report can be recommended as a sound up-to-date guide for those who write and those who read technical reports. It covers adequately the problems of preparing and the problems of publishing reports. One might wish for a short chapter on how to eliminate useless reports and another on how to please all readers of a report but this undoubtedly is getting over into the realm of S_2—the definitive treatment.

MARTIN S. PETERSON
Chicago, Illinois

Selected Abstracts*

ANALYTICAL METHODS

A plan for studying the accuracy and precision of an analytical procedure.

LINNIG, F. J., MANDEL, J., AND PETERSON, J. M. *Anal. Chem., 26,* 1102-10 (1954).

Methods are presented for detecting the sources of variability in the results which reduce the precision of an analytical procedure. Segregation of errors and detection of sources of variability facilitate their elimination or control and lead to a more realistic estimate of the limitations of the method. The segregated relative-type and constant-type errors may be helpful in the quant. study of the chem. factors involved in some equil. reactions.

Spectrophotometric determination of theobromine and caffeine in cocoa powders.

ENGLIS, D. T., AND MILES, J. W. *Anal. Chem., 26,* 1214-18 (1954).

The method is based on a batch-wise H_2O extn. of cocoa in the presence of MgO. The ext. is clarified with Zn acetate and K ferrocyanide. Theobromine is purified by adsorption and elution on columns of Fullers' earth. Caffeine is purified and sepd. from theobromine by a $CHCl_3$ extn. of an ext. made alk. by NH_3. The alkaloids are measured by a spectrophotometric detn. The method claims better accuracy and requires less time than existing methods.

Colorimetric determination of propionaldehyde.

JONS, L. R., AND RIDDICK, J. R. *Anal. Chem., 26,* 1035-8 (1954).

Propionaldehyde reacts with ninhydrin in concd. H_2SO_4 to produce a deep red-blue color suitable for spectrophotometric analysis. The method is specific for propionaldehyde in the presence of several other aldehydes.

Determination of the humidity of a gas with Karl Fischer reagent.

CAPITANI, C., AND MILANI, E. *Chimie e Industria (Milan), 36,* 177-83 (1954); *Anal. Abstr., 1,* No. 1762 (1954).

Full details are given for the detn. of the moisture content of gases, particularly of C_2H_2, by bubbling them through Karl Fischer reagent contained in a suitably modified Meyer tube. The error is ± 2%.

* These Selected Abstracts are made available to FOOD TECHNOLOGY through the cooperation of Associate Editor H. A. Campbell and the General Foods Corporation of New York, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

(Continued on page 16)

Season's Greetings!
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Kansas City
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Happy and Prosperous New Year.
President

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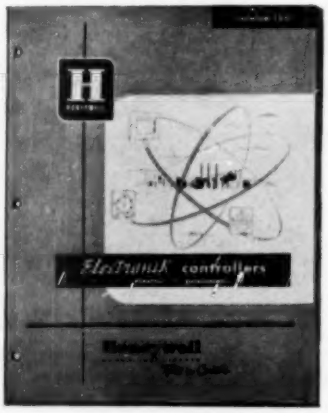

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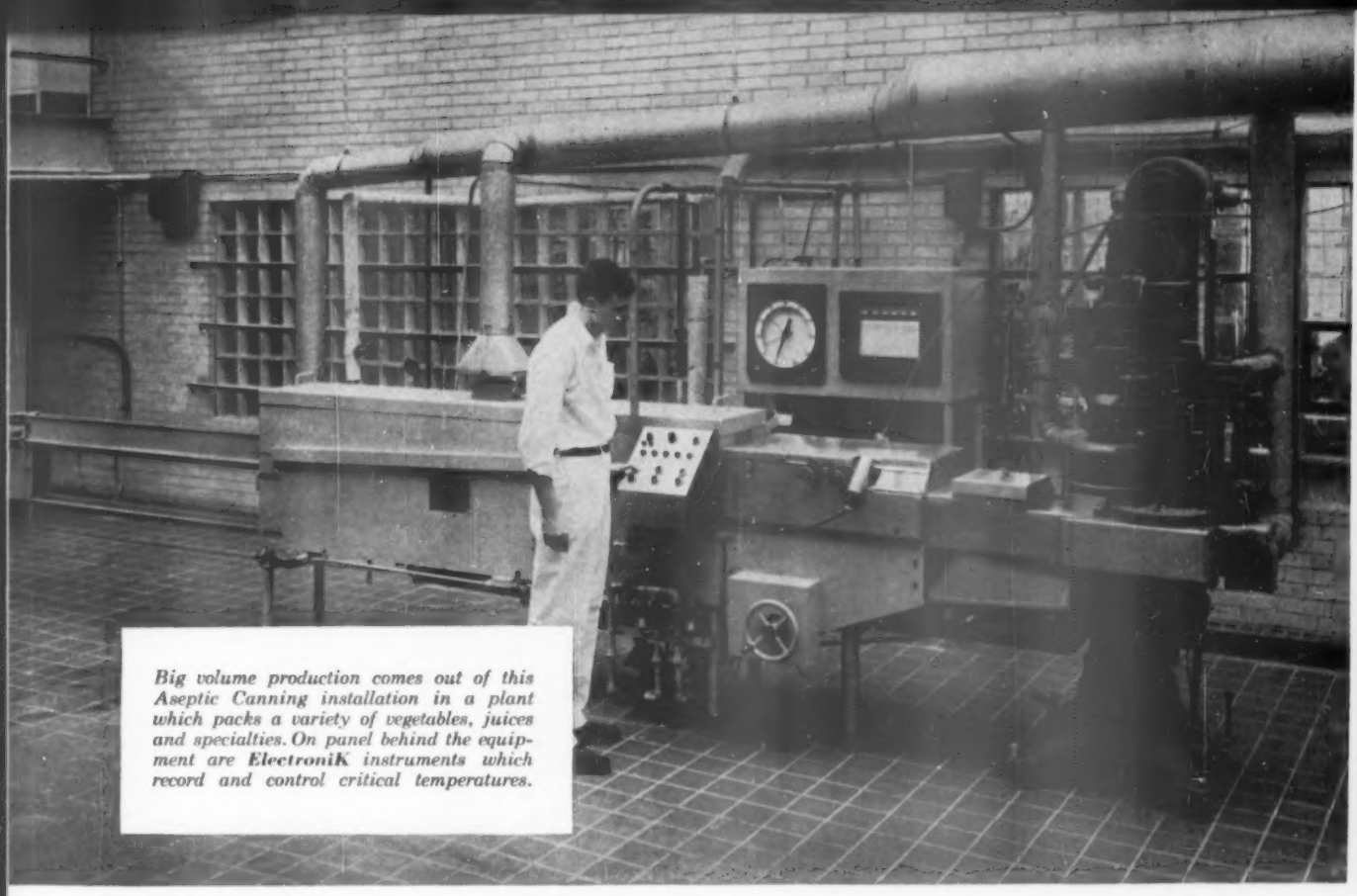

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SELECTED ABSTRACTS

(Continued from page 12)

The analysis of hops.

VERZELE, M., AND GOVAERT, F. *Wallerstein Lab. Communs., 17,* 119-25 (1954).

A new method for hop analysis eliminates the use of more than 1 solvent and can be performed in about 1 hr. The method is based on total extn. of the bitter acids of hops by C_6H_6 and on the chromatographic sepn. of the soln. obtained. An appropriate silica gel is used as adsorbent. Humulon (α-acid) is then detd. polarimetrically, lupulon (β-acid) by potentiometric titration.

Biuret method for soluble whey proteins in nonfat dry milk solids.

SALWIN, H. *Food Research, 19,* 235-45 (1954).

The method, compn. and properties of whey, interference by non-protein components, and analytical details which influence reliability of method are discussed.

A wettability method for powdered milk.

ASHWORTH, U. S., AND GUNTHARDT, H. *J. Dairy Sci., 37,* 863-8 (1954).

A method for measuring the first step in the dispersion of milk powder, that of wetting the powder with H_2O, is discussed. This standard procedure is simple to use, has a reproducibility within approx. 5% and shows great sensitivity as a test for detg. the manuf. and storage conditions of whole milk powders.

A chromatographic method for the estimation of oleic and linoleic acids in the presence of straight-chain saturated fatty acids.

CROMBIE, W., COMER, R., AND BOATMAN, S. G. *Nature, 174,* 181-2 (1954).

A method for the quant. sepn. of mixts. of lauric, myristic, linoleic, palmitic and oleic acids is described.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Lipase. A review.

HERRINGTON, B. L. *J. Dairy Sci., 37,* 775-89 (1954).

Research on the mechanism of the production of a bacterial proteinase. I. A new technic for the determination of a proteinase by the coagulation of milk.

GORINI, L., AND LANZAVECCHIA, G. *Biochim. et Biophys. Acta, 14,* 407-14 (1954).

The technic uses a dispersion of skimmed, powd. milk at low concn. dissolved in a buffered medium. It can be used for the assay of the proteinase of *Coccus P.*, since the proteolytic and coagulating activities are caused by the same active center of a single protein; and especially applicable in following the kinetics of proteolytic enzyme formation by a bacterial culture growing in complex media.

Lysine destruction in casein-glucose interaction measured by quantitative paper chromatography.

PATTON, A. R., SALANDER, R. C., AND PIANO, M. *Food Research, 19,* 444-50 (1954).

Objectives of this investigation were to evaluate the precision of the quant. paper chromatography method, to establish the destruction of lysine in casein with greater certainty, and to measure the extent of such destruction due to the carbonyl-amino reaction under selected conditions of treatment. Under the conditions employed, the most severe loss of lysine occurred from autoclaving with moist heat. Without glucose no significant destruction occurred.

The interaction of dyes with proteins on paper with special reference to paper electrophoresis.

FRANGLEN, G. T., AND MARTIN, N. H. *Biochem. J., 57,* 626-30 (1954).

The results suggest that existing quant. methods of analysis by paper-strip electrophoresis require reassessment.

Synthesis of model, high molecular weight peptides by the mixed carbonic-carboxylic acid anhydride procedure.

VAUGHN, J. R., AND EICHLER, J. A. *J. Am. Chem. Soc., 76,* 2474-6 (1954).

This method of synthesis has been extended to the prepn. of 2 high mol. wt., optically active peptides, in each of which no amino acid unit is repeated. As model compds., a neutral hexapeptide and a basic octapeptide are described.

MICROBIOLOGY

Salmonella infections.

Food, 23, 283 (1954).

Two unusual forms of food poisoning are discussed: one originating in a meat pie factory and the other from unpasteurized milk.

The effect of naturally occurring plant constituents on the heat resistance of food spoilage organisms.

LABAW, G. D. *Dissertation Abstr., 14,* 909-10 (1954).

EtOH and H_2O exts. of carrot, celery, chard, chicory, cucumber, green bean, green pepper, okra, onion, rhubarb, sweet corn, tomato and turnip were screened against typical test microorganisms. Some were found to reduce markedly the heat tolerance of the spores.

Acetic acid oxidation by Escherichia coli: Evidence for the occurrence of a tricarboxylic acid cycle.

SWIM, H. E., AND KRAMPITZ, L. O. *J. Bacteriol., 67,* 419-25 (1954).

Quantitative significance of the tricarboxylic acid cycle.

Ibid, 426-33.

I. It is concluded that the lack of incorporation of isotope into an added carrier cannot be considered conclusive evidence against the occurrence of this compd. as an intermediate. II. Expts. with acetate-1-C^{14} showed that succinate was an end product of the oxidation and that the respiratory CO_2 was not labeled. By mass analysis of the succinate formed from acetate-2-C^{13}, it was possible to distinguish between succinate synthesized from acetate via the tricarboxylic acid cycle and that formed by oxidative condensation.

Bactericidal activity of certain fatty acids.

KARABINOS, J. V., AND FERLIN, H. J. *J. Am. Oil Chemists' Soc., 31,* 228-32 (1954).

Fatty acids in the C_6 to C_{12} range are bactericidal to a no. of different organisms, and this activity is markedly enhanced with increasing acidity. Optimum bactericidal activity to *Staphylococcus aureus* was exhibited by undecylic acid.

Growth and mutation of bacteria during continuous irradiation.

RUBIN, B. A. *J. Bacteriol., 67,* 361-8 (1954).

Growth was observed to occur at a rate equal to nonirradiated controls, and the max. crop of cellular material was also equal. Only the period before the inception of growth (lag) increased as a function of a dose. Under these conditions the mutation frequency increased as a function of total radiation dose, regardless of how much growth (if any) had occurred during irradiation. Nucleic acid content of radiation grown cultures was indistinguishable from controls.

NUTRITION

Failure to produce obesity in the rat following gold thioglucose injection.

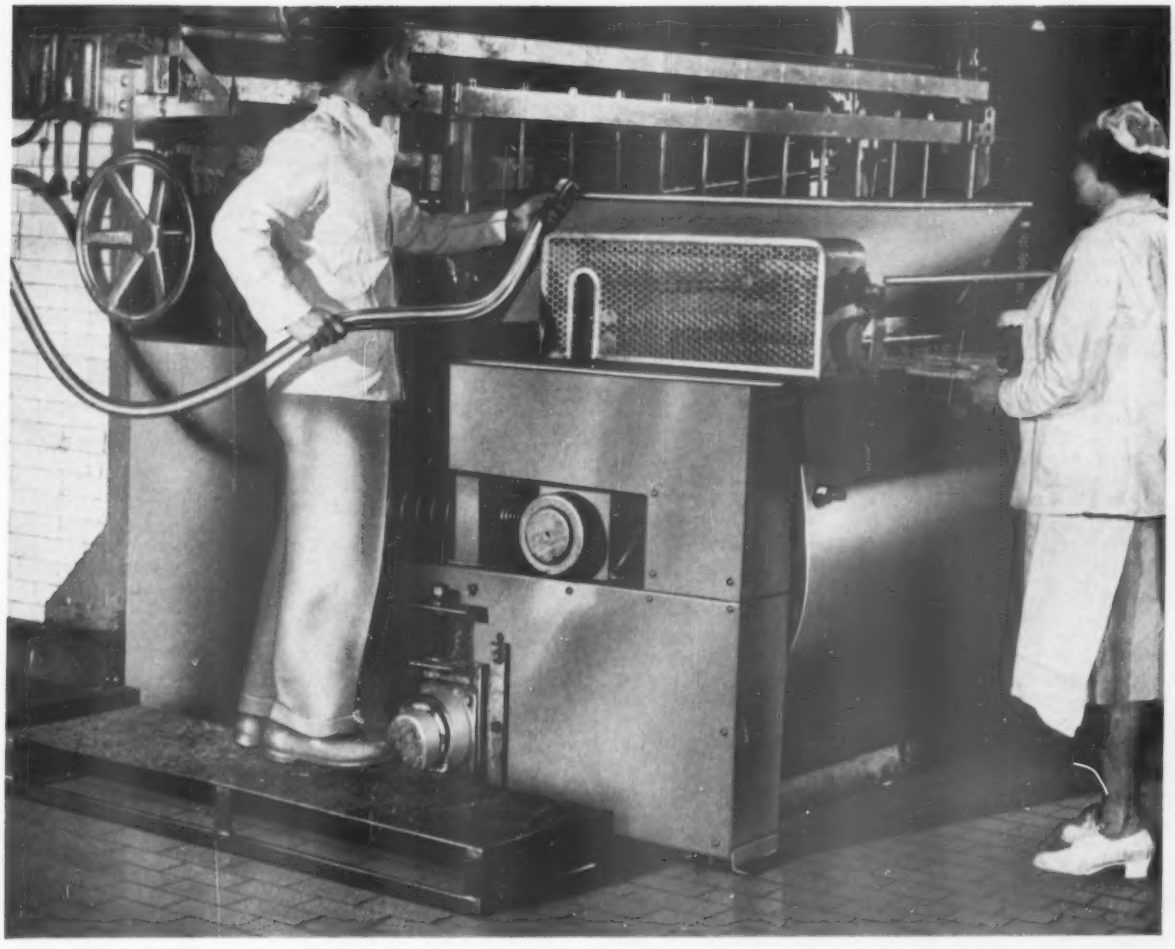
TALBERT, G. B., AND HAMILTON, J. B. *Proc. Soc. Exptl. Biol. Med., 86,* 376-8 (1954).

White rats, originating from the Wistar strain, did not become obese following injections of gold thioglucose under exptl. conditions that have resulted in obesity in 4 strains of mice studied.

Copper metabolism. XII. Influence of manganese on metabolism of copper.

GUBLER, C. J., TAYLOR, D. S., EICHWALD, E. J., CARTWRIGHT, C. E., AND WINTROBE, M. M. *Proc. Soc. Exptl. Biol. Med., 86,* 223-7 (1954).

(Continued on page 18)



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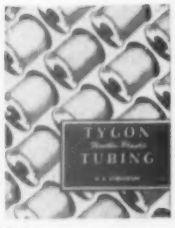

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SELECTED ABSTRACTS

(Continued from page 16)

It is suggested that Mn may form a complex with Cu which makes the latter unavailable or in some manner it blocks the action of Cu-contg. enzymes.

A study of some factors affecting protein utilization with particular reference to the protein-depleted rat.

METTA, V. C. *Dissertation Abstr., 14,* 897-8 (1954).

'Protein utilization on high and low fat diets was studied in growing and protein depleted mature rats. Fat content had no significant effect.

Dental caries in the cotton rat. XV. The effect of tooth maturity and minerals on caries production by semi-synthetic diets.

CONSTANT, M., SIEVERT, H. W., PHILLIPS, P. H., AND ELVEHJEM, C. A. *J. Nutrition, 53,* 29-41 (1954).

Decreasing the Ca level resulted in increased tooth decay in the erupted tooth. Withholding the cariogenic diets until the teeth were more mature decreased the caries susceptibity of the teeth. Acidic inorg., basic or acidic org. salt mixts. gave no protection against tooth decay. A high level of basic inorg. salts resulted in a marked decrease in tooth decay.

Basal metabolism of nineteen children from two to ten years old.

LAMB, M. W., AND MICHIE, J. M. *J. Nutrition, 53,* 93-104 (1954).

The results indicate that age alone is an inadequate criterion by which to classify basal metabolism of children. Basal metabolism changes more uniformly with change in size than in age. The results are more const. when expressed per unit of ht. than per unit of wt. or surface area.

The fortification of bread with lysine. III. Supplementation with essential amino acids.

ROSENBERG, H. R., ROHDENBURG, E. L., AND BALDINI, J. T. *Arch. Biochem. Biophys., 49,* 263-7 (1954).

The nutritional effect which may be obtained by the addn. of lysine, methionine, valine and threonine to a diet composed of com. white bread, fat, salts, and vitamins was investigated. A beneficial effect could be observed only from the addn. of lysine. The results of these expts. indicte that, as far as rat growth is concerned, the only amino acid deficiency in com. white bread is lysine.

PHARMACOLOGY AND TOXICOLOGY

A study of the compatibility of various suspending agents.

LESSHAFFT, C. T., AND DEKAY, H. G. *Drug Standards, 22,* 155-64 (1954).

A change in the viscosity of the supernatant liquids indicated various degrees of compatibility for the 7 insol. drugs tested. The pH detns. indicate that exchange of the Na in the solubilizing groups of the cellulose derivs. with a cation may be a source of incompatibilities with these agents. Methylcellulose-15 cps. was the only suspending agent used in the study which was compatible with all of the drugs tested.

Toxicology of mono-, di-, and tri-propylene glycol methyl ethers.

ROWE, V. K., MCCOLLISTER, D. D., SPENCER, H. C., HOLLINGSWORTH, R. L., AND DRILL, V. A. *Arch. Ind. Hyg. and Occupational Med., 9,* 509-25 (1954).

It is concluded that the mono-, di-, and tripropylene glycol monomethyl ethers present no serious health hazards in industrial handling and use.

Carcinogenic activity of radioactive phosphorus.

KOLETSKY, S., AND CHRISTIE, J. H. *Proc. Soc. Exptl. Biol. Med., 86,* 266-8 (1954).

Single doses of radioactive P, administered internally to rats in amts. of from 1-3.5 μc./g. body wt., proved carcinogenic.

FOOD AND FOOD TECHNOLOGY

BAKING AND BAKERY PRODUCTS

The biochemical functions of soy flour in white bread production.

POLLOCK, J. M. *Dissertation Abstr., 14,* 922-3 (1954).

Study of the different fractions suggests that satisfactory bread contg. a moderate level of soy flour is possible by careful application of heat during soy flour processing, the use of oxidizing agents in the dough and adjustment of fermentation schedules.

FATS AND OILS

Soybean "lecithin" and its fractions as metal-inactivating agents.

EVANS, C. D., COONEY, P. M., SCHOLFIELD, C. R., AND DUTTON, H. J. *J. Am. Oil Chemists' Soc., 31,* 295-7 (1954).

Based on the flavor responses of oils to which phosphatides were added, it appears that phosphatides constitute the precursors for the melony, bitter, cucumber flavors frequently encountered in aged soybean salad oils. These flavor responses are the same as those obtained from added phosphoric acid.

Effects of antioxidants on the thermal decomposition of fat peroxides in vacuo.

PRIVETT, O. S., AND QUACKENBUSH, F. W. *J. Am. Oil Chemists' Soc., 31,* 281-3 (1954).

The antioxidants, α-tocopherol, NDGA and hydroquinone, effected a marked acceleration on the *in vacuo*, thermal decompn. of fat peroxides. Their action, which appeared to be purely catalytic, increased progressively as the concn. was increased.

Consistency of fats plasticized with acetoglycerides.

GROS, A. T., AND FEUGE, R. O. *J. Am. Oil Chemists' Soc., 31,* 377-83 (1954).

Margarine like products of wide plastic range can be prepd. by acetylating lard and cottonseed, soybean, and peanut oils to an acetyl content ranging from about 12-20%. As the acetyl content increased the consistency characteristics of the mixts. improved, that is, the spreads became softer at room temp. and still possessed a very wide plastic range. The latter extend generally from 15° C. to above 40° C.

FISH AND SEAFOOD

Denaturation of myosin during defrosting of frozen fish.

NIKKILA, O. E., AND LINKO, R. R. *Food Research, 19,* 200-5 (1954).

Extent of deterioration in frozen fish largely detd. by condition of fish when frozen. It was established that repeated freezing increases the tendency of the myosin fraction to undergo denaturation.

MILK AND MILK PRODUCTS

The effect of lactose crystallization on protein stability in frozen concentrated milk.

TUMERMAN, L., FRAM, H., AND CORNELY, K. W. *J. Dairy Sci., 37,* 830-9 (1954).

The coagulation of casein during the storage of frozen concd. milk is a direct consequence of the crystn. of the lactose in the milk. The mechanism remains obscure. It is suggested that the sol. lactose in the metacryotic fluid of partially frozen milk may sequester the concd. Ca salts and thereby moderate their destabilizing influence on the colloidal casein. Withdrawal of sol. lactose from the unfrozen phase by crystn. would eliminate the sugar as a stabilizing factor and permit the casein to flocculate.

Nutritive value of milk proteins. II. Stability during sterilization of evaporated milk as determined by the rat growth method.

HODSON, A. Z. *Food Research, 19,* 224-30 (1954).

It appears that the demonstrated amino acid deficiency involves mainly the S-contg. amino acids. This deficiency may be enlarged slightly by the sterilization of evapd. milk and possibly, there may be destruction or loss of availability of the methionine as well as the more labile cystine and cysteine.

Effect of heat during processing of nonfat dry milk solids used for cottage cheese manufacture.

RUDNICK, A. R. *Dissertation Abstr., 14,* 1141 (1954).

An investigation of the heating of skim milk in excess of pasteurization before and during drying and the subsequent

(Continued on page 20)

get bigger sales from a health-minded America

fortify foods and beverages with

PFIZER VITAMINS

● The importance of proper nutrition has come into its own!

In the press, in books, on TV and radio, the public is learning more and more about science's never-ending diet discoveries... finding out that nutritional value is the key to wise food buying.

Now more than ever it will pay you—in increased sales—to carefully consider the vitamin fortification or enrichment of your food and beverage products.

Pfizer, with over 18 years' experience in vitamin production and research, has accumulated much valuable data on food fortification and enrichment. Why not take advantage of this background? Write for the booklet, "Pfizer Products for Food Fortification," for complete information on Vitamin A, Thiamine, Riboflavin, Niacin, Vitamin B_{12}, Vitamin C (Ascorbic Acid).

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Pioneer and Leading Manufacturer of Vitamins Pfizer

SELECTED ABSTRACTS

(Continued from page 18)

alteration in the body qualities of cottage cheese made from that milk led to a no. of conclusions related to the moisture expulsion of the acid curds.

PEANUTS

Rapid curing adversely affects quality of peanuts.

BAILEY, W. K., PICKETT, T. A., AND FUTRAL, J. G. *Peanut J., 33,* 17+, June, 1954.

Shelling properties and edible quality closely assocd. with drying rate. Adverse effects avoided by discontinuing rapid drying at 12% moisture. Min. drying time of 4 days recommended.

PECTIN

Methods of grading pectin in relation to the molecular weight (intrinsic viscosity) of pectin.

CHRISTENSEN, P. E. *Food Research, 19,* 163-72 (1954).

Relationship between mol. wt. of pectin and "grade value" was detd. It was shown that proportion between "sag grade value" and "breaking strength grade value" of pectin was not const. but depended on mol. wt.

PESTICIDES

Flavor of peanut butter as affected by aldrin, chlordan, dieldrin, heptachlor and toxaphene used as insecticides in growing peanuts.

GILPIN, G. L., REDSTRÖM, R. A., REYNOLDS, H., AND POOS, F. W. *J. Agr. Food Chem., 2,* 778-80 (1954).

Studies leading to USDA recommendation for use of aldrin, heptachlor, and toxaphene for rootworm control in peanuts are presented. No definite off-flavors detected in resulting peanut butter.

POTATOES

Histological survey of conditions influencing texture in potatoes. I. Effects of heat treatments on structure.

REEVE, R. M. *Food Research, 19,* 323-32 (1954).

II. Observations on starch in treated cells.

Ibid, 333-9.

III. Structure and texture in dehydrated potatoes.

Ibid., 340-9.

I. Histological observations show that cell sepn. on heating is not directly related to mealiness. Cell sepn. is aided by swelling of the starch within cells. II. Texture of cooked potatoes does not depend on any single factor, but the properties of the gelled starch appear to be most important. The starch quality depends on degree of heat, water and other conditions. III. The influence of blanching time and pectin removal on porosity and swelling is discussed.

PACKAGING

Gas transmission measurement.

ELLICKSON, B. E., HASENZAHL, V., AND HUSSONG, R. V. *Modern Packaging, 27,* 173-5, July, 1954.

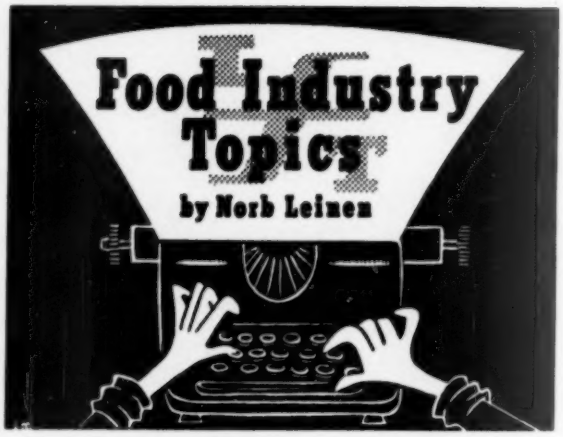
A new method of testing films formed into packages, taking into account the effects of creasing, folding and sealing. The permeability rates of O_2 and CO_2 through various types of laminations are given.

MISCELLANEOUS INFORMATION

Problems of health in the marketing of chemicals.

ROWE, V. K., AND ADAMS, E. M. *Arch. Ind. Hyg. and Occupational Med., 10,* 50-3 (1954).

The chem. manufg. industry, in general, recognizes the responsibility it has for the safe handling and use of its products. The actual hazard to health and the responsibility assumed for safety of use all vary greatly under the influence of the following factors: type and degree of hazardous properties, nature of use, and class and no. of customers. It is possible to obtain information on hazardous properties, to devise precautions which will assure the safety use of chemicals, and to det. the appropriateness of any chemical for a recommended use.



. . . *in the public interest*

How clean is "clean?" By measuring radioactive bacteria with specially designed geiger counters, scientists of the National Sanitation Foundation in the University of Michigan's School of Public Health have discovered new facts about the actual cleanliness of eating, appliance, and preparation surfaces commonly used in the kitchen. Unworn stainless steel, glass, and china, under the same washing conditions, showed a 97-99% removal of bacteria, whereas bacteria removal from aluminum and plastic surfaces was only 56-84% complete. When the same materials had been worn by usage, stainless steel showed a distinct edge over the other materials. A worn stainless surface retained the same characteristic curve as the brand-new product. According to the Foundation, this can be traced to the material's toughness and the fact that there is "no actual glaze to this material under which a more porous surface may exist as in the case of china and plastic materials."

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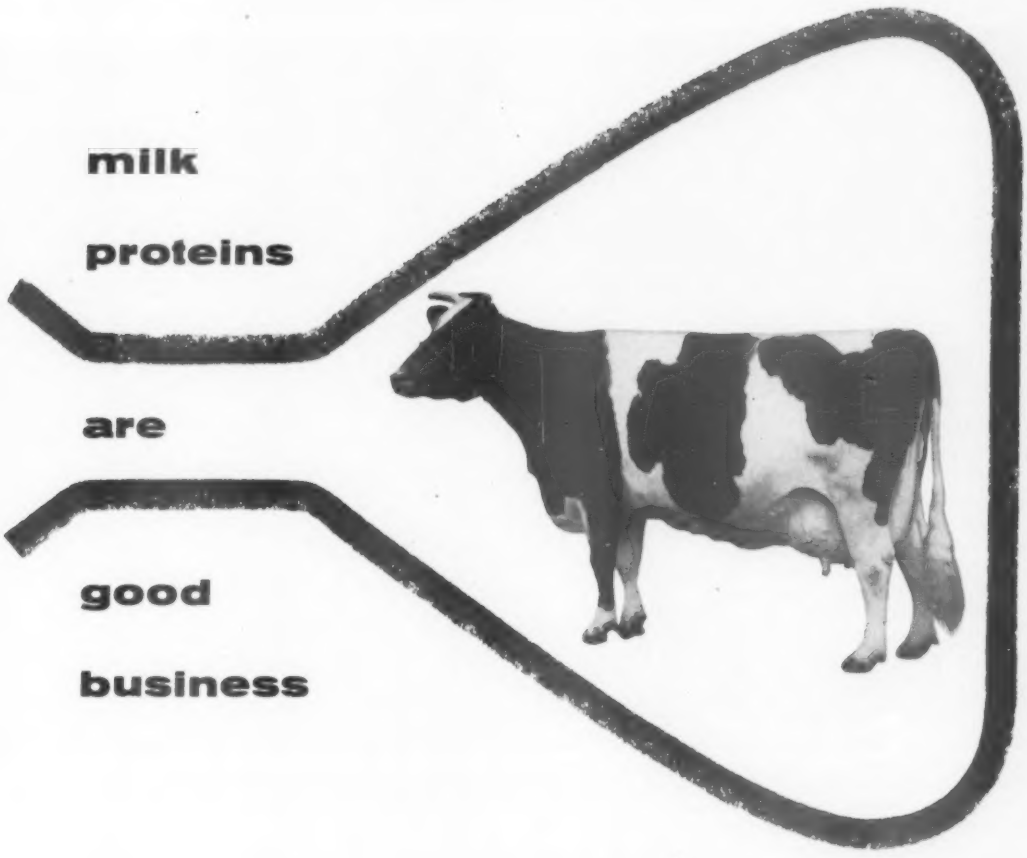
Many aspects of the European economic picture are more favorable than we in this country believe, reports Mr. H. P. Wesemann, first vice president of Fritzsche Bros., Inc., New York City, back from a six-week business trip to Europe. His specific impressions were: England—economy appears to be well on the way up and, as soon as currency is again free, she will be ready to resume her position as an outstanding center of world trade. France—business opportunities have been curtailed, unfortunately, by government controls of financing in connection with licensing of imports. Spain—weather conditions have been generally unfavorable for the products of our industry and almost all prices have advanced as a result. However, the country itself is making rapid strides, due principally to U. S. aid which is everywhere acknowledged as contributing materially to a growing middle class. West Germany—the business outlook is extremely hopeful with tremendous activity and much competition throughout the nation. The

(Continued on page 22)



Today, the public is becoming more and more aware of the need for lower calorie, tissue building, higher protein containing foods for everyone, particularly grownups and the ever-expanding old-age groups. Processors of food products can cash in on this interest by increasing and improving on the protein content of their products with Sheffield milk proteins.

Ice cream, baking, cereal, infant food and meat processors are finding milk proteins a highly desirable supplement to their products. Nature has built extra values into milk proteins, and Sheffield brings these extra values to you. As an example, Sheffield milk proteins are outstanding in nutritional quality because of the fine balance of all essential amino acids.

Sheffield guards the quality of its milk proteins through complete control of the process from farm-fresh milk to the finished product . . . and Sheffield makes these proteins available to you in a wide variety of forms, with characteristics to suit your needs.

Consider these advantages of Sheffield milk proteins: they are fat-free, pleasing to taste, variable in protein content, white in color, and many are sodium-free. In addition, they can serve as excellent dispersing, stabilizing and water-binding agents in many foods. Of course, all meet applicable Federal Food and Drug regulations.

Milk proteins are only one of many products of Sheffield research, all directed toward supplying food processing manufacturers with superior ingredients. Our research department will gladly work with your laboratories to develop new products or improve old ones. For detailed information write Sheffield Chemical Company, Inc., Food Division, Norwich, N. Y.—or to our branch office at 1267 Sixth Ave., New York 19, N. Y.

SHEFFIELD

MILK PROTEIN EDIBLE POWDER
HIGH NITROGEN CASEIN
SODIUM CASEINATE POWDER
CALCIUM CASEINATE POWDER

LEADS THE FIELD IN MILK PROTEINS

A DIVISION OF NATIONAL DAIRY PRODUCTS CORPORATION

FOOD INDUSTRY TOPICS

(Continued from page 20)

influx of refugees from East Germany has contributed to this very competitive situation.

◆ ◆ ◆

Remember the 1955 March of Dimes Campaign, January 3-31. For free ad mats, electros, and other publicity material write: Public Relations Director, The Natl. Foundation for Infantile Paralysis, 120 Broadway, New York 5, N. Y.

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The N. Y. state canning industry's educational program reached a total of 38 scholarships to date as the nine winners of the 1954-55 awards to the food processing course at State University Agricultural & Technical Institute were honored recently at Morrisville, N. Y., by University and industry officials. Scholarships are given by the N. Y. State Canners & Freezers Assn. and individual companies. Center: Assn. President Francis J. Miller, Curtice Bros. Co., shakes hands with Robert H. Eichenberger, Wyoming, N. Y., winner of Haxton Foods, Inc. scholarship. Left to right: Francis E. Almstead, assistant executive dean for the University Institutes and Community Colleges, Albany; Harold L. Aldrich, Oneonta, Pfeiffer's Food Products, Inc. scholarship; Eugene W. Hermenet, Marion, Alton Canning Co. award; Roger W. Brannan, Long Island City, Lyndan Products Div. of S. Gumpert Co., Inc.; Thos. J. Markoski, Albany, the Assn.'s Arthur E. Nash Memorial Scholarship; Chas. S. Korten, New York, the Assn.'s Fern Shannon Scholarship; James F. DeWeaver, Newark, N. Y., Comstock Canning Corp.'s Herbert L. Minaker Scholarship; Samuel B. Lauron, New York, Olney & Carpenter, Inc. award; Philip S. Girmant, Oswego, Libby, McNeill & Libby (Hall, N. Y. branch); Prof. John W. Stewart, acting head of Food Technology Div.; Prof. Royson N. Whipple, acting co-director of the Institute; Wm. H. Sherman, Assn. executive secretary.

◆ ◆ ◆

A Pennsylvania state law banning the sale of soft drinks sweetened with Sucaryl has been declared unconstitutional by the Common Pleas Court of Dauphin County, Pa. The decision was in the case of the Cott Beverage Corp., New Haven, Conn., and an affiliate, The Cott Bottling Co. of Pittsburgh which sought to enjoin Pennsylvania's Secretary of Agriculture and Attorney General from prohibiting distribution of Cott's sugar-free dietetic soft drinks in Pennsylvania. The court declared that Pennsylvania's laws relative to artificially sweetened foods and beverages are "unreasonable and capricious" and constitute an "arbitrary and inconsistent" exercise of police power. The state has appealed the decision to the State Supreme Court.

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Color preference depends upon where you are, according to the Color Research Laboratory of Sun Chemical Corp., 10th St. and 44th Ave., Long Island City 1, N. Y. Where sunlight is abundant, color choice tends toward the strong and brilliant, frequently red, and where sunlight is scarce it leans toward soft, dull blues. Sunlight is, however, only one of many factors that influence color preferences. Color styling, the result of many factors, is sometimes decisive. The resort areas of Florida and Southern California, for example, are strong for pastel tints, whereas the sunny regions of the South and Southwest require intensity and warmth in hue. Specialists in color trends have learned to weigh such factors as hours of sunlight in selecting colors for packages and other merchandise. Although not in itself a final guide, how well (or poorly) a region is endowed with sunlight has a bearing on its color preferences.

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To emphasize the vital role good packaging plays in the successful merchandising of non-food items through supermarkets, the American Rack Merchandisers Institute is holding its first annual Self-Service Packaging Awards competition. A total of 31 awards will be made for the best new self-service non-food packages sold in supermarkets during 1954 in the following categories selected as representative of almost all non-food self-service packages: bag, box, card, label, sleeve, and tag. Award presentation will be made during the joint meeting of regular distributors and associate supplier members at the national convention of ARMI in January at the Congress Hotel, Chicago, January 10-12.

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The outlook for medical education in America has been "visibly brightened" by recent events according to Mr. Geo. H. Coppers, president of National Biscuit Co., and chairman of the Food, Confectionery & Dairy Division of the Committee of American Industry. The CAI is spearheading an appeal of the National Fund for Medical Education for an annual $10,000,000 from industry to keep the nation's medical schools in business. The grant by Congress of a Federal Charter to the National Fund for Medical Education, said Mr. Coppers, puts it on the same plane with the Red Cross and other great public agencies, and emphasizes the fact that medical training in America is a basic national resource. Furthermore, the U. S. Steel Foundation's initial gift to the Fund of $50,000, adds to Federal recognition that of one of the nation's largest industries. The annual goal of $10,000,000 is described as the minimum to keep the medical schools above water without seeking Federal subsidy.

(Continued on page 24)

NATURAL FLAVOR IS NEVER BORN HERE

Nothing yet developed in a laboratory test tube has been able to replace the fulsomeness of natural spice flavor, nor has it been able to approach the other immense advantages of natural spices.

The unique properties nature has conferred upon its spices enable them to offer the food processor plus values of stability and endurance of flavor and all-important anti-oxidation and preservative qualities.

No extraction or essence can duplicate the singular cell structure that surrounds each bit of flavor in natural spices with a protective wall that releases the flavor slowly and lingers from making to eating. Nor, researches prove, does freezing diminish the flavor value of natural spices.

Test after test, conducted by a number of research laboratories and institutes throughout the country, have confirmed scientifically what the consumer has known for centuries: there is no substitute for the satisfying quality, aroma, strength, fullness, body and bouquet of natural spices.

And for over a century — 112 years — KNICKERBOCKER has been supplying food processors with the finest in natural spices, carefully selected, rigidly controlled for quality in grading, packing and delivery.

The difference in cost, if any, is so small as to be insignificant in your over-all costs; it just doesn't pay to use less than the best in natural spices—KNICKERBOCKER.

The difference in taste is great —send for a sample order today and you'll see why.

KNICKERBOCKER *Spices*

KNICKERBOCKER MILLS CO. • 601 West 26th Street, New York 1, N. Y.

Since 1842 America's Leading Importers of Fine Spices

FOOD INDUSTRY TOPICS

(Continued from page 22)

Fresh-frozen poultry is giving consumers the freshness they demand, according to a report by the Poultry and Egg National Board. In addition to freshness, the frozen products offer retailers such advantages as elimination of waiting at the meat counter, no wastage, savings in labor, elimination of time required to draw, cut, and wrap, and no spoilage. According to the Board, a new method of freezing at 72° below freezing has eliminated the need of thawing before cooking—saving time for the housewife.

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Food and grocery store sales of foods packed in fancy metal boxes will be stimulated by the first national promotion ever given decorative tin containers, according to Mr. Harold H. Jaeger, marketing director of the Can Manufacturers Institute, New York City. The campaign is timed to tap peak sales weeks of the current holiday season. Emphasis has been placed on the gift values of candies, cookies, fruit cakes, and biscuits packed in decorative cans which not only protect and preserve the contents but also have re-use appeal. Co-sponsors of the campaign are the U. S. Steel Corp., Natl. Confectioners Assn., American Baking Institute, Natl. Restaurant Assn., and *Look* Magazine.

. . . *things new under the sun*

By grinding whole spice to microscopic fineness, the Wm. J. Stange Co., 342 N. Western Ave., Chicago, has produced a **revolutionary seasoning** which combines the advantages of both ground spice and soluble seasonings. In announcing his firm's new 50-A Seasonings, Mr. Wm. B. Durling also described how they assure food processors constant flavor uniformity, true spice flavor and color, and the assurance of more thorough distribution throughout the finished product. The unique properties are attributed to the microscopic size of the spice particle (50 microns) which is ground twenty times smaller than 60-mesh spice. Thus, with 20 to 100 times more particles permeating the batch, 50-A Seasonings react much like soluble seasonings in that the natural flavor and the spice is instantly available to the food and uniformity of flavor is maintained. Since individual particles are invisible to the naked eye, they eliminate the possibility of unsightly specks.

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Coconut bars containing glycerine **showed no deterioration** in taste and flavor after a year's open storage, according to a recent report on shelf life of such confections, informs the Glycerine Producers' Assn., 295 Madison Ave., New York City 17. Bars made without a humectant lost moisture and fell off sharply in quality under the same conditions. The more stable bar had this formula (ingredients in parts by weight, dry basis): sugar, 40.16; corn syrup, 17.07; coconut, 32.12; salt, 0.60; antioxidant mixture, 0.01; sorbitol, 5.02; and glycerine, 5.02. The full report is contained in the June 1954 issue of *Manufacturing Confectioner.*

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Multi-million dollar savings each year by **preventing mold growth on foods** are now possible and practical according to an announcement by Carbide and Carbon Chemicals Co., a Division of Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17, N. Y. The firm has arranged for a non-exclusive license under The Best Foods, Inc., patent covering the use of sorbic acid for control of mold growth and permitting it to grant sublicenses to its sorbic acid customers. Sorbic acid (not to be confused with ascorbic acid) is being offered at $2.45 per pound—a price considered practical because of the small amounts needed for effective mold control. Temporary permits have been granted by the U. S. Food and Drug Administration to a number of cheese manufacturers to use the material in certain standardized cheeses, pending action on an application to amend the cheese standards to include sorbic acid as an optional ingredient. Further experimental work is being done on other food uses of sorbic acid.

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With a new Ekco-Foil oblong **divided luncheon tray,** school children, hospital patients, and drive-in and restaurant take-out patrons can be served on a silvery platter and be spared the sogginess of paper plates. Complete dinners can be served in the sanitary, three-compartment aluminum tray. Smooth edges of the curled rim eliminate cut fingers, protect over-wrap, and offer a firm seat for closure covers.

(Continued on page 26 following technical papers)

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1954	
December 12-15	American Institute of Chemical Engineers, New York, New York
December 27-30	American Association for the Advancement of Science, University of California, Berkeley, California
1955	
February 21-24	International Food Show, New York, N. Y.
March 7-10	American Society of Bakery Engineers, Edgewater Beach Hotel, Chicago, Illinois
March 13-17	Frozen Food Industry Convention, Hotel Hilton, Chicago, Illinois
March 13-17	National Assocition of Frozen Food Packers, Hotel Hilton, Chicago, Illinois
March 29-30	National Conference of Interstate Milk Shipments, Hotel Peabody, Memphis, Tennessee
March 29-April 7	The 127th National Meeting of the American Chemical Society, Cincinnati, Ohio
April 30-May 2	American Academy of Applied Nutrition, Pasadena, California
June 12-16,	**Institute of Food Technologists, Hotel Deshler, Columbus, Ohio**

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

Filling is all a Matter of Measurement . . .

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Fillers for:

. . . AND EVERY FMC FILLER IS DESIGNED FOR THE MOST ACCURATE MEASUREMENT AT HIGHEST SPEEDS

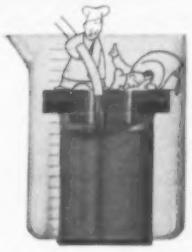
Your business and ours is measuring—measuring valuable products with the *right* combination of accuracy and speed You're assured of these essential qualities in every famous FMC Filler—whether it's designed to fill liquids, semi-liquids or free-flowing granular products . . . in cans, jars or cartons. Check the four food filling principles described here. Find the best FMC Filler for your particular requirements. Then, for the most accurate measuring and filling at high speed, *specify FMC—and save!*

Volumetric Head-Space Filling

FMC No. 18 Pre-Vacuumizing Syruper

FMC 6, 10, 12, 18, 20 and 24 Valve Gravity Syrupers and Juice Fillers

FMC 6 and 12 Valve Pulp Fillers



This filling principle is employed in brining and syruping fruits and vegetables. It's an automatic, gravity type of filling in which liquid is filled or added to a product up to a pre-determined head space level. Displacement pads of a given specific volume are incorporated on the valves, and enter the container to provide the necessary displacement for the liquid. Filler speeds from 50 to 350 CPM.

Volumetric-Container Measuring

FMC Hand Pack Filler

Used for semi-automatic hand pack filling, this principle is utilized for products such as tomatoes, French-style string beans, whole and sliced beets, leafy vegetables, halved peaches, whole apricots—most any product that can be handled by hand, except those that must be placed in cans in an exact position. The can size alone serves as the measuring unit. Filler speeds up to 200 cans and more per minute, depending on nature of product.

Volumetric Pre-Measuring (Gravity) Fillers

15 and 30 Valve Fil-Mor Fillers

Liquid Fillers, 6, 10, 12, 18 and 24 valves

Carton Fillers, Models 9 and 15

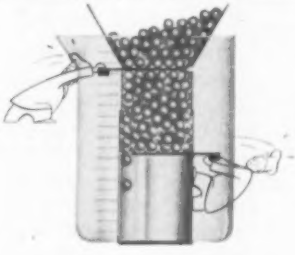
8 and 15 Station Pea and Bean Fillers

Mara-Pak Carton Filler

Soup Fillers

Utility and Multi-Utility Fillers

Automatic Hand Pack Filler

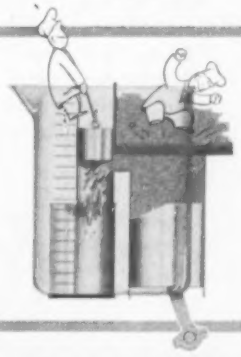


This filling operation is incorporated into various FMC Fillers used on products such as fruit juices, diced fruits and vegetables, and oysters. The product being filled is pre-measured in a chamber and discharged into the container by gravity. This principle is generally used for machines that are completely automatic in operation. A number of special chambers are available for liquids. Filler speeds from 50 to 500 CPM.

Volumetric Pre-Measuring (Plunger) Fillers

M&S Fillers, 6, 9, 10, 15, 20 and 30 Pockets

FMC-Hansen 12 Pocket Filler



The Plunger or Piston filler also employs the principle of product pre-measuring and is recommended for such products as oil, dog food, sliced strawberries, spaghetti, citrus concentrates, tomato paste and relish. In operation, fillers of this type pre-measure the product into a chamber, from which it is then positively ejected into the container by a piston. Filler speeds from 60 to 750 CPM. Can handle all types of containers.

FOOD MACHINERY AND CHEMICAL CORPORATION

Canning Machinery Division

General Sales Offices:

WESTERN: SAN JOSE, CALIFORNIA **EASTERN:** HOOPESTON, ILLINOIS

the greatest advance in meat seasoning

Scientifically manufactured MAGNA SPICE CONCENTROLS have modernized the seasoning of meats by making available the true flavor components of herbs and spices in the most concentrated form known to Science . . . yet easily processed in your own plant. All the flavor is released immediately. Each batch of your product is uniformly and identically seasoned.

- **Out perform crude herbs and spices.**
- **Easy to measure — easy to mix.**
- **No spoilage.**
- **Cut seasoning costs up to 40%.**

Write for the new MM&R booklet — "The Greatest Advance in Meat Seasoning."

MAGNUS, MABEE & REYNARD, INC.

Since 1895 • One of the World's Greatest Suppliers of Essential Oils and Flavors

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221 NORTH LaSALLE STREET, CHICAGO 1, ILL., U.S.A.

FOOD INDUSTRY TOPICS

(Continued from page 24)

The pre-shaped, rigid aluminum foil container is ¾" deep and measures 8½ x 6½" across the top. It can be saved when the meal is finished and used as a relish tray on outings or for other purposes. A companion round Ekco-Foil container has the same efficient features. For further information write Ekco Products Co., 1949 N. Cicero Ave., Chicago.

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The Rapids-Standard Co., Inc., Rapistan Bldg., Grand Rapids 2, Mich., offers detailed information on the benefits to be gained by installing a Rapistan flow system to move stocks. If desired a qualified applications engineer will be assigned to make on-the-spot suggestions without obligation.

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Accurate measurement of very small, rapidly varying currents is provided by the Cary Model 36 Vibrating Reed Electrometer, made by Applied Physics Corp., Pasadena, Calif. Its principal application is the rapid recording of ion currents from the analytical mass spectrometer, providing several times as much sensitivity as other amplifiers used for this purpose. Other applications include the rapid measurement of nuclear and X-radiations, photo-electric and other electron emission phenomena, insulator and semi-conductor research. The same firm also announces its Model 14 Cary Recording Spectrophotometer, with wave length range extended to include near infrared and with increased photometric accuracy. The apparatus incorporates a newly designed double monochromator and flicker beam photometric system.

◆ ◆ ◆

Development of a new line of **quick adjustable casters** designed to compensate for uneven floor surfaces by giving controlled support, stability and portability to kitchen and laundry appliances, office furniture, industrial carts, or institutional and hospital equipment was announced recently by the Adjustable Caster Co., 1411 Walnut St., Philadelphia. Available in a wide range of models for installation on wood, metal, tubing, or angle iron, the "Scruswiv" adjustable wheel type casters are readily levelled to correct high and low spots by a simple turn of the adjusting nut with the fingers. A further feature is locked adjustment which prevents turning of the adjusting nut when subjected to vibrations when used on motorized equipment.

◆ ◆ ◆

Operational improvements in Clark Equipment Company's redesigned Electric Stoway stand-up type, end-control fork truck include easier steering for reduced driver effort, more efficient hydraulic control of lifting and tilting mechanisms for smoother handling of fragile loads, positive hydraulic braking for increased safety, and improved maintenance accessibility. More information on the improved Stoway can be obtained by writing to the Industrial

(Continued on page 32)

Mineral Nutrition — The Role of Trace Elements[a]

C. A. ELVEHJEM
University of Wisconsin, Madison

(Manuscript received July 1, 1954)

The term "trace element" has been applied in the biological sense to those mineral elements which in extremely small amounts play some part in the nutrition of plants and animals. There has always been something fascinating about this term, largely, perhaps, because scarcity is a necessary condition for value. The term came into existence about the same time that workers were recognizing vitamins which are organic counterparts for trace mineral elements. Both function in small quantities but may have a very profound effect when they are absent or present in inadequate amounts. Thus, minute quantities of fluorine in our drinking water, amounts which we cannot see or taste, may have a profound effect on the incidence of dental caries. The iodine in our table salt, which cannot be distinguished, may determine whether growing children have normal or abnormal thyroids. Furthermore, the minute traces of copper in iron salts used for the treatment of simple anemia may determine whether this therapy is effective or largely ineffective.

From a biochemical point of view there is nothing spectacular about the function of these trace minerals. In fact the specific action of such elements as iodine and fluorine may be much less complex than the function of such elements as sodium and potassium. Since trace elements are needed in very small quantities, it has taken chemists many years to demonstrate their necessity in plants or animals, to perfect methods for estimating these elements in biological material, and finally to establish some quantitative figures for their need.

There are 20 or so mineral elements which occur commonly in foods in trace amounts or in amounts less than .005%. Of this group, 8 may be listed as important to animal life. These include copper, cobalt, fluorine, iodine, iron, manganese, molybdenum and zinc. Some of these may not be essential for the plant, especially fluorine and iodine and perhaps cobalt. Two other elements, boron and silicon, are probably essential for plants but may have no specific function in the animal. In addition, we have a list of elements which may be naturally present in foods or may gain access from industrial processes. In the former group we might include aluminum, boron, and selenium and a few examples of the latter group would be arsenic, chromium, lead and so on.

THE MINERALS ESSENTIAL TO HUMAN NUTRITION

From a nutritional point of view, especially if we limit our discussion to human nutrition, it is perhaps necessary to consider only 8 of the above elements. In this discussion I would like to give a little historical background of the work leading to the recognition of these minerals as essential nutrients, then discuss briefly some of the newer developments, and conclude by summarizing very briefly the present day significance of these mineral elements.

Iron. Iron was recognized as a constituent of blood in the early 1700's. In fact from the earliest times iron was considered an important therapeutic factor and the subject of profound medical interest. Even copper was recognized in plants in 1816, and in 1848 Deschamps revealed that a relationship existed between the amount of copper in plants and the amount in the soil in which they were grown. In spite of this early work there was a controversy for many years over the relative value of organic versus inorganic iron. Bunge maintained that egg yolk was an excellent source of iron for the treatment of anemia and that the iron in egg yolk was present in the so-called organic form. Modern workers may not realize the importance of the impact of these early conclusions on the experimental studies conducted 25 to 30 years ago. In fact it took considerable experimental work and much courage to clearly conclude that inorganic phosphorus could serve as the sole source of this element for building the complex phosphorus containing compound in the animal body. In the case of iron the question was clearly settled in 1927 when we showed that inorganic iron can be built into hemoglobin in the animal body when adequate quantities of copper are also present. We also demonstrated that copper was not directly needed for the absorption of iron from the gastrointestinal tract but that it was needed for the conversion of iron into hemoglobin after the iron was absorbed or stored in the liver. This conclusion has been questioned recently by certain workers, but I think it is clearly evident that the original findings stand and that copper does have an indirect influence on the absorption of iron since, when more iron is built in the hemoglobin, naturally more iron will be absorbed from the intestinal tract. This does not mean that copper is essential for the actual absorption of iron.

The ability of cytoplasm to build inorganic iron into complex molecules such as hemoglobin and cytochrome is most remarkable. A number of years ago I grew yeast on a medium very low in iron and copper and this yeast had a very low content of cytochrome. When both iron and copper were added to the medium a much higher level of cytochrome was obtained and the production of cytochrome would take place in a matter of a few hours when these minerals were added. It is clear, therefore, that simple salts of iron and copper can be utilized by most living tissues and that these elements and their salts can be used directly in human and animal nutrition.

Theoretically then, there should be no difficulty in supplying these elements in adequate amounts under all conditions. However, practical problems do occur; namely, when certain iron salts are added they may accelerate the destruction of certain organic compounds in the food, especially vitamins. It then becomes a problem of food technology to process the foods in such a way as to prevent one component from being destructive to other components. Thus in enrichment of bread and flour it is important to use forms of iron which may not be destructive to other nutrients in flour but at the same time use forms which may be available to the animal or the human.

In the case of iron we have excellent examples of certain organic forms that are not readily digestible and the iron is not absorbed from the intestinal tract. Hemoglobin and most iron containing porphyrins fall into this class and certain foods may carry a relatively large amount of the total iron in these forms. For example, it has been known for a number of years that in vegetables, such as spinach, only about 20% of the iron is available. On the other hand we must realize that some of these foods are very rich in total iron and therefore even if only a small percentage of the iron is available they serve as important sources of this element. In this connection it is important to emphasize that we may not have identified all the interesting

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forms of iron in biological material. For example, in 1952 Neilands *(13)* isolated from the smut fungus *Ustilago sphaerogena*, an interesting iron compound which has been called ferrichrome.

Copper. It is also important to emphasize that 25 years ago it was impossible to prepare purified rations and omit single mineral elements as we wished. Therefore the early work on iron and copper was done with milk diets because milk happens to be low in both of these elements. Even at that time certain workers experienced difficulty in obtaining a copper deficiency since certain samples of milk were contaminated with copper during processing. Shortly thereafter it became easier to carry on these studies since much of the copper equipment was replaced by stainless steel and other metals. However, I understand that the rigid exclusion of copper from milk is no longer of such significance since the oxidized flavor is not so readily produced in homogenized milk. While the copper was being removed from our milk supply there was also great interest in the use of highly refined cereals for infant feeding. These refined cereals together with orange juice were the only additions made to milk diets for the young infant. It was not surprising, therefore, that we found considerable incidence of anemia in children during that period. This difficulty has practically disappeared today for several reasons. One, many of the infant foods are now fortified with iron and copper. Two, other foods such as egg yolk, vegetables and very recently meat are added very early to the infant's dietary. I mention these facts to emphasize that our problems change from decade to decade, and it is important for us to know the basic facts and then apply these basic facts in a common sense way to our modern food processing.

Manganese. The use of milk diets also allowed a demonstration of the essential nature of manganese. Young rats placed on milk diets would develop anemia; when iron and copper were supplied, this anemia did not occur but the animals failed to grow normally. When manganese was added in addition to iron and copper, normal growth was obtained and it was possible to carry the rats on mineralized milk through many generations. While it is relatively simple to produce a manganese deficiency in experimental animals and to find several enzyme systems in which manganese is essential, a deficiency of this element under practical conditions is indeed rare. This is because manganese is widely distributed in food materials; even when certain individuals restrict their diets to certain groups of food there is no danger of deficiency. In other words manganese is similar in this respect to certain of the B vitamins. For example vitamin B_6 and pantothenic acid are definitely essential for normal nutrition, but a deficiency rarely occurs because of their wide distribution in a great variety of food materials. Manganese is needed in smaller quantities than either iron or copper. In animal nutrition the ratio is about as follows: 10 of iron, 1 of copper and .1 of manganese. The fact that the requirement is less is not necessarily significant if the distribution of this element is correspondingly less in biological materials and therefore in foods.

Again one cannot generalize with safety since certain combinations may either increase the requirement of a certain trace element or decrease its availability. A good example is a manganese deficiency in chickens which results in perosis or slipped tendon. During the years between 1930 and and 1935 a number of workers showed that excessive amounts of calcium salts increased the occurrence of perosis. In 1937 Wilgus, Norris and Heuser *(25)* reported that the addition of small amounts of manganese would prevent the disease on normal rations. This was soon verified in many laboratories and as most of you know it is common practice today to add a manganese salt to most poultry rations. In this case the action of manganese may be related to its action on phosphatase since it was found that phosphatase of the blood and bones of chicks afflicted with perosis was markedly lower than normal.

Zinc. When we turn to zinc we find that it was impossible in the early studies to use milk diets for the production of the deficiency of this element since milk contains considerably more zinc than any of the other three elements. In the early studies on zinc it was necessary, therefore, to struggle with purified diets and I may add that it was a real struggle because at that time several of the B vitamins were still unknown. Today it would be much simpler to produce a purified ration low in zinc because all of the known vitamins are fairly well established. When zinc was shown to be essential it was natural to expect that one of the functions of zinc was to supply this element for the building of carbonic anhydrase. However, much to our surprise, we were unable to find any decrease in the amount of this enzyme in animals suffering from severe zinc deficiency. A lowered intestinal phosphatase activity in zinc deficient rats was found *(6)*. This merely indicates that the most obvious function of a nutrient may not be the function which is most limiting in living matter. Again the wide distribution of zinc and a relatively low requirement does not place it in a critical group of trace elements.

Cobalt. Cobalt is perhaps the most interesting of all the trace elements because it is needed in such extremely small amounts and because it functions in living tissues through its presence in a vitamin, namly, vitamin B_{12}. As far as is known today, vitamin B_{12} is the only vitamin which contains a mineral element. It is also significant that the first evidence for the essential nature of cobalt was not demonstrated through the use of laboratory animals but through the use of large farm animals such as the cow and sheep. In fact, back in 1930, Dr. Stare and I worked very hard in an attempt to produce a cobalt deficiency in rats but without success. In 1909 the Michigan Agricultural Experiment Station described a disease of dairy cattle locally known as Grand Traverse or lakeshore disease. The animals showed general emaciation, incoordination of gait, depraved appetite, and usually died of the disease unless they were moved to other areas for grazing. In 1935 and 1936 workers in Australia and New Zealand demonstrated that cobalt would cure a similar deficiency observed in animals in their country. It is only very recently that a complete understanding of the function of cobalt in the treatment of these conditions and the mechanism of action has been established. It appears clear today that the administration of cobalt in these animals allows synthesis of vitamin B_{12} in the rumen and this vitamin is then absorbed supplying the requirements of the animal and also allowing the deposition of some of the vitamin in the liver. The importance of liver in the treatment of pernicious anemia has been known for over 25 years and its value is now known to be due to the presence of vitamin B_{12}. The vitamin must come from the rumen of the cow rather than from the natural food because plant material is practically devoid of vitamin B_{12}.

So far no one has been able to demonstrate that plants need cobalt. However, certain molds, especially aureomycin, contain large quantities of vitamin B_{12} and the amount of vitamin produced can be increased by the addition of cobalt. We have here then a very interesting situation; namely, that cobalt may be utilized in the inorganic form in ruminants but that cobalt must be supplied as the organic vitamin B_{12} in other animals. This difference is due to the fact that in one case microorganisms in the digestive tract build cobalt into the organic form. The animal's system in each case must be supplied with vitamin B_{12} but the variation in species is due to the syntheses taking place in the digestive tract. The question may be asked, can cobalt function in the place of vitamin B_{12} in animals such as the rat and chick? Extensive studies in our laboratory *(8)* have shown that cobalt has no growth-promoting effect in rats fed diets low in vitamin B_{12} while the administration of vitamin B_{12} gives a typical response. Burns and Salmon *(3)*, observed some growth stimulation upon the addition of certain levels of cobalt to rats and chicks. However, the responses were rather erratic. It could also be mentioned in this case that in the digestive tract of many animals all the cobalt is not present in vitamin B_{12} but you may have pseudo forms of vitamin B_{12} which also carry cobalt *(9)*. Furthermore, the vitamin B_{12}, at least in human subjects, is not absorbed unless it is in the presence of the intrinsic factor. It may also be interesting to point out that an animal such as the mink requires exceedingly high levels of vitamin B_{12} and that part of this requirement can be supplied by synthesis of vitamin B_{12} in the intestinal tract *(7)* if the proper form of carbohydrate is used. Animals receiving starch as the carbohydrate may develop severe vitamin B_{12} deficiency which will respond either to the administration of vitamin B_{12} or to a change in carbohydrate from starch to sucrose. This is one of the few cases where we have observed a greater synthesis of a

vitamin when sucrose is fed rather than a less soluble carbohydrate such as starch.

MINERAL DEFICIENCIES IN SOIL AND WATER

These few examples clearly demonstrate that the need for mineral elements and the form in which these elements must be supplied may vary greatly depending upon the type of living cytoplasm with which we are dealing. If we limit our discussion to the animal kingdom, we can definitely say that the only two mineral elements which must be supplied as organic compounds are cobalt and possibly sulfur. It is surprising then that we still hear statements as follows: "Minerals taken into the system through plant foods are more available than are minerals taken separately." This does not mean that plants are not important carriers of mineral elements whether in the organic or inorganic form. Actually the availability of the minerals in soils may alter the composition of plants sufficiently to be of critical nature in the nutrition of animals and even humans restricted to foods of a given area. However, with few exceptions, humans under modern conditions are rarely restricted to one area sufficiently to make their diet limiting even though the soil in that particular area may not supply adequate amounts of the given element.

An element may be sufficiently limiting in the soil to reduce the production of the crop or to alter the susceptibility of that crop to disease or infection. Thus boron may have a very definite influence on the production of certain plants but the amount of boron in that plant is not related in any way to the adequacy of the nutritional value of food produced on that land. In fact it may be possible to fertilize the soil sufficiently to produce a luxuriant growth which in turn may produce a plant which does not supply an adequate amount of a given mineral. I might mention in this connection that in certain areas of this country the soil is sufficiently high in selenium to produce plants carrying an appreciable amount of this toxic element. Wheat grown on these areas, when fed to experimental animals, will produce selenium toxicity. However, this has little practical significance since during the normal milling process wheats from many areas are mixed and the resulting flour is so low in selenium as to have no toxic effect. A few cases have been reported of ranchers living on food produced in a very limited area and sufficient selenium ingested to produce a toxic effect.

This brings us to two trace elements which have a closer relationship to the soil than any of those discussed so far. The inverse relationship between the iodine content of the soil and water and the occurrence of goiter in man is amply substantiated. In fact the early observations of iodine deficiency were made in Switzerland where groups of individuals were limited to very narrow areas of land and you would have within a relatively few miles groups of humans suffering from severe iodine deficiency and other groups showing no goiter whatsoever. Similarly, in this country, the incidence of goiter is higher in certain inland areas than in areas along the seacoast where the iodine content of the water and certain sea foods is higher. However, no one has suggested the addition of iodine to the soil in order to effect an increased intake of this element. In fact, if this were done, the plant would merely carry the iodine as inorganic iodine since iodine is not essential except in those organisms where thyroxin functions.

I suppose we should not leave iodine without mentioning that we have here an example of a real problem encountered by food technologists. The problem of fortifying salt with iodine and making this salt available to our general population has been one which has attracted much attention and has induced many possible suggestions, none of which has brought us a successful program. The compulsory iodization of salt through legislation has received much consideration but there are many pros and cons to this program. It is rather ironical that in the case of iodine we have a trace element which today is relatively cheap and we have methods of adding iodine and stabilizing the salt; in other words the technological problems have been solved but the problems dealing with human psychology and human reaction have not been solved.

A similar relationship has been established between the fluorine content of soil and water and the incidence of dental caries. Most of this is dependent upon the water as the carrier since very large amounts of fluorine would have to be added to the soil to increase the fluorine content of plants significantly. In practice then iodine today is supplied largely through iodized salt while fluorine additions are made through water. There may be objections to both procedures and as our knowledge increases better methods of adding these materials may be developed. It is not my purpose today to enter into a controversy regarding fluoridation of water except to say that its usefulness has been clearly demonstrated. I would not suggest that this is the only procedure for the control of dental caries or that it will continue to be used when more effective procedures are developed. From our point of view I think it is important to emphasize that at the present time fluorine is not considered an essential element in nutrition since animals have been grown through several generations on diets which are exceedingly low in fluorine. This statement may need to be modified since so far no one has used a diet completely devoid of fluorine. The amount needed to protect against dental caries is larger than the minimum amount, and it is obvious that normal teeth can be developed in the absence of this added fluorine.

NEWER DEVELOPMENTS

This brings us to a consideration of the newer developments in the field of trace elements. It is obvious that much of the early work has been done on a nutritional basis, that is, the production or selection of diets or rations low enough in the trace element in question to produce reduced growth or other symptoms. Many difficulties have been encountered but in spite of this the specific deficiencies have been produced in many cases. However, as I have just indicated, this has been impossible in the case of fluorine and it has been impossible in the case of boron and I well remember the very extensive procedures which we carried out in order to purify all the ingredients of a synthetic ration in an attempt to produce a boron deficiency in rats. Even in the case of cobalt it is practically impossible to prepare a diet low enough in cobalt to produce a deficiency in the ordinary laboratory animal. It is possible to produce a B_{12} deficiency in the rat under special conditions but these diets still carry appreciable cobalt. In the case of ruminants, where the requirement is apparently much higher, it is possible to clearly demonstrate a cobalt deficiency. Because of these difficulties we have seen in the past few years a somewhat different approach to the study of trace elements in nutrition.

As our knowledge of enzymes has increased, many workers have studied the effect of nutrition on the level of certain enzymes in tissues of the animal. I have already referred to early studies on phosphatase in manganese deficiency and carbonic anhydrase in zinc deficiency. Some helpful information was gained but the studies were not too revealing. During the past two or three years we have seen a most interesting development regarding the relation of molybdenum to enzyme changes in animal tissues. The enzyme which has received greatest attention is xanthine oxidase. Westerfeld and Richert *(23)* at Syracuse found that the intestinal xanthine oxidase level in rats was reduced when these animals were fed certain restricted diets especially diets low in protein or specific types of protein. Later fractions were prepared which enhanced the xanthine oxidase activity of the rat intestine. These concentrates were made from soybean flour and from liver fractions. De Renzo and coworkers *(4)* of the Lederle Laboratories first showed that molybdenum would function in place of this factor. Richert and Westerfeld *(18)* also

found molybdenum to be active and that the activity of various foods in this respect correlated in general with the molybdenum content of foods. It is interesting that the total molybdenum content of foods determined chemically was always greater than the amount determined biologically *(24)*. The availability ranged from 50 to 100%. So far no other manifestation except a low intestinal xanthine oxidase activity has been demonstrated in rats on diets low in molybdenum. Again we do not know whether it would be possible to reduce the molybdenum content of the ration sufficiently to alter the activity of xanthine oxidase in other tissues or alter other enzymes.

In our laboratory xanthine oxidase has been used as a measure of the biological value of proteins and the availability of certain amino acids. Changes in the xanthine oxidase content of liver were used as the criterion. We *(10)* have clearly demonstrated that the addition of extra amounts of molybdenum has no influence on the changes in xanthine oxidase content of the liver as produced by feeding different proteins or levels of proteins. Apparently, the ordinary diets contain sufficient molybdenum to supply the requirement for the production of xanthine oxidase in the liver. In this connection it is interesting to point out that De Renzo *et al.* concluded that the maximum daily requirement to produce a saturation level of intestinal xanthine oxidase is on the order of 0.2-0.3 micrograms of molybdenum per rat. Back in 1942 we *(20)* concluded that if rats needed molybdenum the requirement was less than 0.5 micrograms per rat per day. Changes in xanthine oxidase in the content of the intestinal lining are interesting but we know little about the relation of these changes to optimum nutrition. Since high levels of molybdenum produce diarrhea and certain digestive disturbances, it would be interesting to see if this condition is related in any way to the changes in xanthine oxidase. There is no question but what xanthine oxidase contains molybdenum since Green and Beinert *(5)* have shown that xanthine oxidase is a molybdo-flavoprotein. It appears that there are two molecules of flavin adenine dinucleotide and one atom of molybdenum per molecule of the enzyme with the molecular weight of about 230,000. Since the preparation of this paper Richert and Westerfeld *(19)* have presented data to show that milk xanthine oxidase contains iron, riboflavin, and molybdenum in a ratio of 8:2:1 and has a minimum molecular weight of 320,000. Molybdate has also been identified as a constituent of nitrate reductase *(15)*. Although this enzyme does not take part in animal metabolism, it is interesting to find that molybdenum is a constituent of quite a different type of enzyme. Other flavo proteins have also been shown to contain heavy metals as part of their prosthetic groups. The enzyme which catalyzes the first oxidative step in the conversion of lower fatty acids to acetyl coenzyme A has been designated butyryl CoA dehydrogenase. Its color is a deep brilliant green and upon further study it was found that the enzyme contains flavin adenine dinucleotide and ionic copper as integral parts *(12)*. It contains 1.2% riboflavin and .345% copper. The molar ratio of copper to flavin equals 2. Studies have also been presented *(11)* to show that reduced diphosphopyridine nucleotide cytochrome reductase is a ferro-flavo protein. In this case the ratio of iron to flavin equals about 4. These few examples merely indicate a great degree of activity in the present studies on the trace elements in specific enzymes. Apparently, additional demonstrations of this kind will follow in the next few years.

From a nutritional point of view we should emphasize that it is rather doubtful that a deficiency of trace elements will produce a reduced amount of these essential enzymes, at least sufficiently to produce disturbed metabolism. Undoubtedly, other needs for trace elements will show alteration before changes in the enzymes occur. Nevertheless, sudden deficiencies, or more important, balances between certain trace elements, may affect the activity and concentration of some of the important enzymes. Some of these interrelationships have been observed using microorganaisms. For example, Waring and Werkman *(22)* found that the activity of formic dehydrogenase was reduced in *Aerobacter indologenes* when these cells were grown on deficient medium. Jane Pinsent *(17)* has extended these studies and has shown that traces of selenite and molybdate as well as iron are essential for the formation of an active formic dehydrogenase by strains of coliform organisms. The selenite and molybdate have no influence on growth but did have a specific effect on the formation of active dehydrogenase. Therefore, it is unknown whether these ions are actually incorporated into the enzyme molecule or are indirectly concerned with the synthesis of certain parts of the protein molecule. Miss Pinsent also found that if the medium contains nitrate, tungstate competitively antagonizes the effect of molybdate. However, tungstate is without effect in a media free of nitrate. The work of Waring and Werkman *(22)* on bacterial metabolism substantiates the statement made earlier regarding the priority of trace elements for certain enzyme systems. They found that the iron needs of the cytochrome system appear to be met first since catalase and peroxidase enzymes may be reduced to less than 5% of normal activity before the cytochrome system is affected. Upon further deficiency of iron it was possible to reduce the cytochrome content to the point where no absorption bands were observed. However, these cells still maintained a normal oxygen uptake. Another interesting relationship observed in microbial metabolism is the finding of Neilands *(14)* that the addition of zinc to actively growing cultures of *Ustilago sphaerogena* produced an immediate drop in the ferrichrome concentration of the cells. Twelve hours after the zinc addition an increase in cytochrome was evident. This may mean that ferrichrome is functioning as a precursor of cytochrome c although this has not been clearly demonstrated. In any case it again indicates a very interesting interrelationship between two trace elements.

The interrelationship between molybdenum and copper has been known for many years. Molybdenum toxicity has been noted under natural grazing conditions and has been produced experimentally in farm and laboratory animals. Ruminants seem to be more subject to toxic effects than are non-ruminants. However, toxic effects have been produced in rats and guinea pigs

and the condition has been alleviated by the administration of copper. Recently this relationship has been studied in rabbits by Arrington and Davis *(1)* and toxic effects have been produced when .1% or more of molybdenum was fed. The symptoms were very similar to those which have been described for copper deficiency in the rat. The only difference noted was that there was no achromotrichea in the molybdenum toxicity. The addition of copper to the ration prevented the development of toxicity and administration of copper caused rapid recovery in rabbits with severe toxic symptoms. Apparently it took about .1 as much copper as molybdenum to reverse the toxic effect. We might consider one more example. Van Reen *(21)* has shown that feeding excessive zinc to rats (500-700 mg. %) produced a marked reduction in liver catalase and cytochrome oxidase activation. Feeding of copper brought these values back to normal but did not counteract growth inhibition produced by excessive zinc. It is obvious that in the cases that I have cited excessive quantities of one trace element have been added in relation to the others. This situation may not occur in normal human nutrition although it does emphasize to food technologists that care should be taken to prevent large variations in the ratios between trace mineral elements.

We should also give additional consideration to the effect of trace elements on the intestinal flora. We have studied the effect of type of carbohydrate, level of fat and protein, and the effect of antibiotics on the intestinal flora but we have given little consideration to the effect of mineral elements whether they be macro or micro elements. It is obvious from work on cobalt that the flora may be altered to a considerable extent and that the presence or absence of cobalt may determine the type of organic nutrients manufactured by the flora. We also know that derivatives of arsonic acid may function like antibiotics in the stimulation of growth in young animals. Again the mechanism is unknown but it does indicate that further work is necessary. Apparently, inorganic arsenic is not active but this is another example of the action of trace elements. We cannot leave this discussion without also indicating that fluorine, at least to some extent, functions by preventing the bacterial action on the surface of teeth. In this case its action is undoubtedly facilitated by the higher concentration of fluorine at the actual surface where the bacteria grow. At least from present knowledge I think we can safely say that the level of fluorine now used in drinking water has little or no effect on the type of bacterial flora in the tract.

SOME CONCLUSIONS

I believe it is obvious from the discussion I have given that each element needs to be considered separately and that no generalizations can be made which will take in all the elements. However, from a nutritional point of view, especially from the point of view of food technology, we can make certain conclusions. In the first place there is little likelihood of a deficiency of the trace elements except perhaps the so-called critical trace elements, iron and iodine. These can be added without much difficulty if we can agree on the philosophy of food fortification. There is little difficulty regarding the addition of mineral elements since the simple salts are all available except in the case of cobalt which needs to be added as vitamin B_{12}. We should give consideration to foods that are prepared for special purposes, especially in infant feeding where milk may be the basis for the product. However, we need to give little consideration to the loss or inactivation of the elements during processing such as we need to do in the case of certain vitamins. In reference to special foods, I might mention the interesting observation made by Nishimura *(16)* that suckling mice deprived of colostrum and allowed to suckle female rats at the latter stages of lactation suffered severe zinc deficiency. This deficiency was immediately corrected by the addition of zinc salts. This emphasizes that the colostrum was rich enough in zinc to take care of the needs but when the young were shifted to a different type of milk, difficulties arose.

Finally, we must object to the extravagant claims made for trace elements. They are not a cure-all. They will not cure brucellosis *(2)*. It is, of course, fascinating to find molybdenum in xanthine oxidase and cobalt in vitamin B_{12} but, after all, these findings, all long in coming, are no different from the finding that hemoglobin contains iron.

LITERATURE CITED

1. Arrington, L. R., and Davis, G. K. Molybdenum toxicity in the rabbit. *J. Nutr.*, **51**, 295 (1953).
2. Berman, D. T. Trace elements in brucellosis. *J. Am. Med. Assoc.*, **153**, 643 (1953).
3. Burns, J. M., and Salmon, W. D. Effect of cobalt on growth of chicks and rats. *Fed. Proc.*, **13**, 452 (1954).
4. De Renzo, E. C., Kaleita, E., Heylter, P., Oleson, J. J., Hutchings, B. L., and Williams, J. H. The nature of the xanthine oxidase factor. *J. Am. Chem. Soc.*, **75**, 753 (1953). Also *Arch. Biochem. Biophysics*, **45**, 247 (1953).
5. Green, D. E., and Beinert, H. Xanthine oxidase, a molybdo-flavoprotein. *Biochim. Biophys. Acta*, **11**, 599 (1953).
6. Hove, E., Elvehjem, C. A., and Hart, E. B. The effect of zinc on alkaline phosphatases. *J. Biol. Chem.*, **134**, 425 (1940).
7. Leoschke, W. L., Lalor, R. J., and Elvehjem, C. A. The vitamin B_{12} requirement of mink. *J. Nutr.*, **49**, 541 (1953).
8. Lewis, U. J., Tappan, D. V., and Elvehjem, C. A. A new and biologically different form of vitamin B_{12}. *J. Biol. Chem.*, **194**, 539 (1952).
9. Lewis, U. J., Tappan, D. V., and Elvehjem, C. A. Properties and distribution of vitamin B_{127}. *J. Biol. Chem.*, **199**, 517 (1952).
10. Litwack, G., Fatterpaker, P., Williams, J. N., Jr., and Elvehjem, C. A. Studies on the response of liver xanthine oxidase to dietary protein in weanling rats. *J. Nutr.*, **52**, 187 (1954).
11. Mahler, H. R., and Elowe, Dorothee G. DPNH-cytochrome reductase, a ferro-flavoprotein. *J. Am. Chem. Soc.*, **75**, 5769 (1953).
12. Mahler, H. R. Studies on the fatty acid oxidizing system of animal tissues. IV. The prosthetic group of butyryl coenzyme A dehydrogenase. *J. Biol. Chem.*, **206**, 13 (1954).
13. Neilands, J. A crystalline organo-iron pigment from rust fungus (*Ustilago sphaerogena*). *J. Am. Chem. Soc.*, **74**, 4846 (1952).
14. Neilands, J. B. Factors affecting the microbial production of ferrichrome. *J. Biol. Chem.*, **205**, 647 (1953).
15. Nicholas, D. J. D., and Nason, H. Molybdenum and nitrate reductase. *J. Biol. Chem.*, **207**, 353 (1954).
16. Nishimura, H. Zinc deficiency in suckling mice deprived of colostrum. *J. Nutr.*, **49**, 79 (1953).

17. PINSENT, JANE. The need for selenite and molybdate in the formation of formic-dehydrogenase by members of the Coli-aerogenes group of bacteria. *Biochem. J.*, **57**, 10 (1954).

18. RICHERT, D. A., AND WESTERFELD, W. W. Isolation and identification of the xanthine oxidase factor as molybdenum. *J. Biol. Chem.*, **203**, 915 (1953).

19. RICHERT, D. A., AND WESTERFELD, W. W. The relationship of iron to xanthine oxidase. *J. Biol. Chem.*, **209**, 179 (1954).

20. TERESI, J. D., ELVEHJEM, C. A., AND HART, E. B. Molybdenum in the nutrition of the rat. *Am. J. Physiol.*, **137**, 504 (1942).

21. VAN REEN, R. Effects of excessive dietary zinc in the rat and the interrelationship with copper. *Arch. Biochem. Biophysics*, **46**, 337 (1953).

22. WARING, W. S., AND WERKMAN, C. H. Iron deficiency in bacterial metabolism. *Arch. Biochem.*, **4**, 75 (1944).

23. WESTERFELD, W. W., AND RICHERT, D. A. Liver and intestinal xanthine oxidase and relation to diet. *J. Biol. Chem.*, **192**, 35 (1951).

24. WESTERFELD, W. W., AND RICHERT, D. A. Distribution of the xanthine oxidase factor (molybdenum) in foods. *J. Nutr.*, **51**, 85 (1953).

25. WILGUS, H. S., NORRIS, L. C., AND HEUSER, G. F. The role of manganese and certain other trace elements in the prevention of perosis. *Science*, **84**, 252 (1936).

The Use of Ionizing Radiations in the Eradication of Insects in Packaged Military Rations[a]

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The use of ionizing radiations for the control of insect infestation in certain packaged military ration components was investigated, and determinations were made of the doses of high-energy cathode rays, X-rays, and gamma rays needed to destroy all metamorphic forms of different insect species. Organoleptic tests were made with cereal and fruit ration bars irradiated at dose levels found necessary for insect destruction, and the effects of these radiations on the functional properties of some packaging materials were studied. Based on the information obtained, specifications are given for the radiation sterilization of a typical ration component, and a conservative cost analysis of such a process is made.

Insect infestation of commercial cereal grains, cereal products, dried fruit products, and military ration components made therefrom has for many years been a serious problem in this country, as well as in tropic areas. Prevention of initial insect contamination of materials from which food products are made is extremely costly and sometimes impossible. Often infestation is carried over from the raw materials to the finished product.

A number of methods for destroying insects in stored cereal and fruit products have been devised. These include high frequency heating, sonic treatment, and centrifugation. Chemical treatments have been used in many instances. As each of these methods has particular disadvantages, there is still a continual search for newer approaches to the problem of eradication of insects in food products.

Several years ago preliminary studies (unpublished) in the Department of Food Technology at the Massachusetts Institute of Technology showed that ionizing radiations could be effective in the destruction of insects in all stages of development and that the energy required for their destruction would be of relatively low magnitude compared with that required for the destruction of microorganisms such as bacteria, yeasts, and molds. Consequently the use of these radiations for treating insect-infested materials appeared to be feasible not only from a practical economic viewpoint but also with respect to elimination of undesirable side-effects, which often result when high-energy radiation is employed. However, many problems still exist relating to the use of ionizing radiations for the eradication of insects in commercial products and military ration components.

Briefly, these problems can be divided into four categories:

(1) those related to the effects of ionizing radiations on insects (adults, other stages of metamorphic development, eggs, and ability of adults to produce fertile, viable eggs);

(2) those related to the effects of ionizing radiations on the quality characteristics of food products, particularly flavor, appearance, and texture;

(3) as most food products must be packaged and as irradiation after packaging would offer important advantages to the process, those problems related to the effects of ionizing radiations on functional properties and physical characteristics of packaging materials; and

(4) problems related to the economic usefulness of ionizing radiations, should favorable solutions to other problems be forthcoming.

To study these problems, the following objectives were established:

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[b] Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

[c] Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois.

(1) to determine the doses of ionizing radiations required to destroy, in their various stages of development, several species of insects, especially those found in cereal products and in dried fruits; to destroy insect eggs, and prevent reproduction;

(2) to determine quantitatively the effects of ionizing radiations on functional properties and physical characteristics of commonly used packaging materials;

(3) to ascertain the relationship between the dose required for the destruction of insects in rations and ration components and the flavor of these rations;

(4) from the information obtained as a result of the foregoing experimentation to set specifications for a process of insect destruction in ration components by ionizing radiations, and to compare this process with other methods of eradication.

Experiments designed to provide information by which these objectives might be attained, the results of these experiments, and their significance are herewith presented and discussed.[4]

EFFECTS OF IONIZING RADIATIONS ON INSECTS

Experimental. *The insects and their culture.* Five species of insects normally found in infested cereal and fruit products were employed as experimental animals. These species were:

Tribolium confusum (Jacq. Duval)	Confused flour beetle
Tenebrio molitor (L.)	Yellow mealworm
Oryzaephilus surinamensis (L.)	Sawtoothed grain beetle
Rhizopertha dominica (Fab.)	Lesser grain borer
Lasioderma serricorne (Fab.)	Cigarette beetle

All insects were cultured in loose media in Mason jars. Cloth was substituted for the paper disks in the jar covers, to provide adequate ventilation. The jars were then placed in special aluminum trays, to confine any insects that might escape and to prevent infestation of the rooms in which they were kept. All insect cultures were maintained in an incubator, in which the temperature was kept constant at 78° F. and the relative humidity was above 50%. Larvae, pupae, and eggs were separated manually by sifting; a household sifter was used for the larger forms, but 42 gg. bolting cloth was necessary for the eggs.

Irradiation of insects. All radiation exposures were done with isolated metamorphic forms (adults, larvae, or pupae in groups of 20 to 30 for each test; eggs in groups of 50 for each test) in a small amount of flour, contained in appropriate glass receptacles. For each set of irradiated samples a control set was kept under identical conditions, except for irradiation.

Insect counts after irradiation. After the exposure, the insects were incubated at 78° F. in ventilated containers. The relative humidity of the incubator was 50%. Counts were made at intervals of 1 to 2 days, and the number of living and dead as well as the results of observations on development and reproduction were recorded. The insects were considered dead when stimulation with a dissecting needle produced no reaction. The cultures, however, were not discarded until microscopic examination of the test insects showed beyond doubt that they were dead (discoloration and drying out of the bodies) and until a period equivalent to at least twice the normal span of egg viability had elapsed, during which time no hatching had occurred.

Sources of radiations. Gamma, cathode, and X-rays were employed in these studies. The source of gamma radiation was a kilocurie Cobalt-60 source, which has been described in detail elsewhere *(7, 8)*. This source had been previously calibrated by physical and chemical means, so that the dose received by each sample could be easily calculated from the known exposure time. During the period of the tests reported here, the intensity of the Cobalt-60 source was from 1300 to 1650 rep[5] per minute. Cathode rays were derived from a 3 m.e.v. Van de Graaff electrostatic generator, also described in detail elsewhere *(14)*.

The energy of the electrons used in all cases was 2.5 million volts. The doses delivered were calculated from the current and voltage meter readings and checked with ferrous-ferric dosimeter solutions *(8)*. X-rays were derived from the electrostatic generator by inserting a gold target in the tube between the source and the sample, to convert the energy of the accelerated electrons into X-rays *(13)*. The energy of the bombarding electrons was 3 m.e.v. and the average energy of the X-rays, 1.6 m.e.v.

Results. Data from many experiments relating to survival and development, in which gamma, cathode, and X-rays were applied to adults, larvae, pupae, and eggs of the five species of insects previously mentioned can be summarized as follows:

Studies in which the efficiencies of the several types of radiation were compared indicated that gamma, cathode, and X-rays were equally effective when applied in doses such that the same amounts of ionizing energy were absorbed by the insect samples. A typical example of the effects of similar doses of these radiations on the survival of adults of *Tribolium confusum* is presented as Figure 1. With doses of approximately 200,000 rep, none of the adult insects survived longer than 8 days.

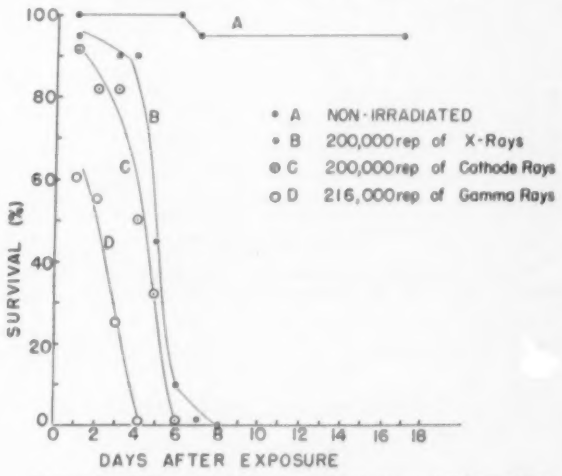

Figure 1. Effects of similar doses of three different types of ionizing radiations on the survival of adults of T. confusum.

The differences in the radiosensitivities of the several insect species and in the radiosensitivities of their metamorphic forms were relatively small. These are shown in part by Figure 2, which presents the effects of irradiation with gamma rays on the mean survival time of adults of four insect species. From this it appears that the adults of *T. confusum* and *R. dominica* are slightly more resistant than those of *O. surinamensis* and *L. serricorne*.

The rate of death is dependent on the dose used, higher doses causing death more rapidly (Figure 3). In this case, none of the adults of *O. surinamensis* survived longer than 12 days after an exposure of 50,000 rep as cathode rays, or longer than 10 days after a dose of 100,000 rep. None survived longer than one day after irradiation with 400,000 rep. Similar results were obtained with other insects and with other forms than adults.

After exposure to ionizing radiations in low doses, in some instances as low as 12,500 rep, the insects in all forms were destroyed within a few weeks. In general, however, much higher

[4] This research *(9)* was supported by the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois. The statements made and the conclusions drawn are to be assigned to the authors and do not necessarily have the indorsement of the Department of Defense.

[5] The unit of radiation dose used in this paper for all types of radiation is the rep (roentgen-equivalent-physical). This unit is defined in terms of the energy absorbed by the sample, and one rep is considered to be the equivalent of 93 ergs per gram of absorber.

doses (ranging from 300,000 to 600,000 rep) were required to destroy the insects immediately.

Development of insects from one metamorphic form to another and also effective reproduction was prevented by relatively low doses, ranging from 25,000 to 50,000 rep. These doses would eventually kill all exposed individuals. In a typical experiment with *R. dominica*, for example, the metamorphosis of larvae in a control culture began during the third day. By the end of the observation period most of the surviving insects had already reached the adult stage. In each of the cultures irradiated with 25,000 and 50,000 rep only one larva pupated but died within 24 hours after pupation. In another experiment, 80 control adults of this same species produced 424 eggs and 205 larvae hatched from the eggs. In cultures irradiated at 25,000 rep, only 21 eggs were found; three larvae hatched from these eggs but died within 24 hours.

These results are representative of many obtained with the insect species studied. They demonstrate that, in general, low doses of ionizing radiations, irrespective of the source, will effectively destroy insect life as typified by the species studied.

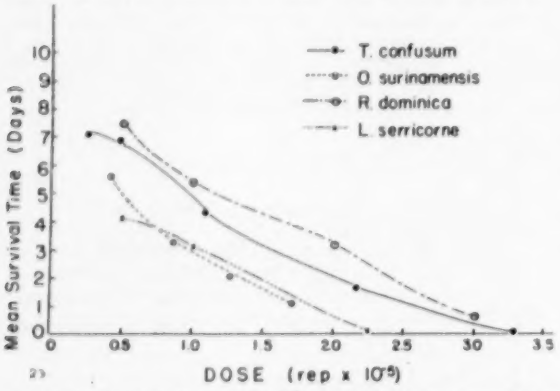

Figure 2. Effects of irradiation with gamma rays on the mean survival time of adults of four insect species.

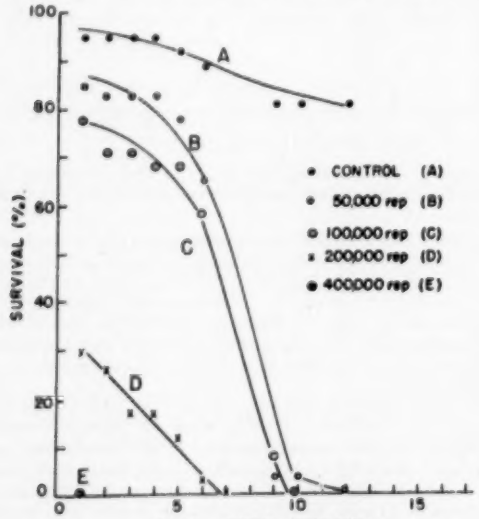

Figure 3. Effects of different doses of 2.5 m.e.v. cathode rays on the survival of adults of O. surinamensis.

EFFECTS OF IONIZING RADIATIONS ON PACKAGING MATERIALS

Experimental. A number of materials used in food packaging were irradiated with cathode rays and subsequently tested with respect to their water-vapor and oxygen permeabilities, grease-proofness, and other characteristics. All irradiations were conducted with the electrostatic source of radiation mentioned previously. In general, two series of experiments were conducted, one in which the doses given were slightly greater than those required for bacterial destruction (2 to 4 million rep) and the other in which the doses were at a high level of radiation (5 to 20 million rep). All tests on the irradiated packaging materials were started within 24 hours after the exposure.

Effects of sterilizing doses of cathode rays. Water-vapor permeability tests were carried out on a number of materials by means of both the standard gravimetric test *(11)* and a new electric hygrometric test *(1, 15)*. No significant change in water-vapor permeability of any of the materials irradiated at a level of 3.5 million rep was detected by either of these two methods. Oxygen permeability was studied with only one material, 0.0020-inch polyethylene film irradiated with 3.0 million rep. The oxygen permeability of this film, as determined by the method of Landrock and Proctor *(3, 4)*, was found statistically to be no different from that of unirradiated film.

A number of materials were irradiated with 3.5 million rep and tested for grease-proofness according to the standard turpentine test *(5, 12)*. None of the irradiated materials showed any significant change in grease-proofness.

Five representative materials were tested in a Suter Tensile Strength Tester after irradiation with 3.5 million rep. Only one of these, a coated, moisture-proof cellophane, showed a significant decrease in tensile strength.

Twenty-eight materials were tested by standard methods for internal tearing strength *(10)*, after irradiation with 3.0 million rep. As the Elmendorf tearing strength tester was found to be only moderately accurate in tests on plastics, the results on these materials serve only as approximations. In general, however, no significant difference in tearing strength between the irradiated samples and their controls was detected.

Two materials, heat-seal coated 0.0007-inch aluminum foil laminated to 40 pound Kraft and polyethylene 18 pound coated on 35 pound Kraft, were irradiated at a dose level of 2.0 million rep after heat-sealing. Testing of these materials on a Suter tester after they had been conditioned at 78° F. and 50% relative humidity showed that there were no significant differences in the strength of seal of the irradiated as compared with the unirradiated samples.

While this research was in progress, it was observed that the color of Saran (100 gauge) was changed after irradiation. To measure quantitatively this change, a sheet of material was irradiated with 2.5 million rep and the color produced determined spectrophotometrically with a Beckman spectrophotometer. Transmission decreased generally throughout the range 350 to 700 mμ. At 350 mμ, where the greatest change occurred, a decrease in transmission of 15% was observed.

Because the question arose whether irradiation woud produce an objectionable odor in polyethylene film that might be transferred subsequently to foods packaged in it, a sensory test was designed to provide an answer. Homogenized milk, margarine, and water were packaged in polyethylene film that had been irradiated with 3.5 million rep. The same materials in unirradiated film served as controls. After 24 hours at refrigerator temperature, the foods were submitted to a triangle taste test. Neither the milk nor the margarine held in irradiated film was significantly different in flavor from the controls. There was a significant difference in the flavor of water stored in the irradiated film. The hedonic scores obtained on these samples were not, in any case, significantly different.

Several materials (a coated, moisture-proof cellophane, 450 gauge; pliofilm, 140 gauge; 0.002-inch polyethylene; and Saran, 100 gauge) were irradiated with 20 million rep of cathode rays. Visual inspection showed that only the Saran appeared affected, irradiation resulting in considerable darkening of the film, shrinkage, and loss of flexibility. The extent of the color change of the Saran was indicated by spectrophotometric measurements. These showed that at 400 mμ, where the greatest change occurred, the transmission of light had decreased approximately 90%.

Tests on the water-vapor permeabilities of these four films, made according to the hygrometric method, demonstrated that the permeability of the coated cellophane was increased from

three to four times by irradiation at the level of 20 million rep. This increased permeability was probably due to the effect of the high level of irradiation on the coating. The permeability of the pliofilm was increased slightly, but that of the conditioned irradiated Saran and of the polyethylene did not change significantly.

Samples of several heat-seal materials were irradiated at dose levels of 2, 5, 10, 15, and 20 million rep. All materials irradiated with doses above 10 million rep showed signs of deterioration and of decrease in both tensile strength and heat-seal strength.

It may be generally concluded that irradiation of packaging materials at levels below 1.0 million rep does not affect their functional or physical properties significantly.

EFFECTS OF CATHODE RAYS ON FLAVOR OF RATION COMPONENTS

Experimental. Cereal ration bars were subjected (from two sides) to irradiation at dose levels ranging from 70,000 rep to 1.5 million rep. Fruit ration bars were irradiated from two sides with 150,000 and 230,000 rep. Several experiments were made with a prepared gingerbread mix irradiated at 120,000 and 85,000 rep and with a Brownie mix at 105,000 rep. These typical ration components, after irradiation, were submitted to flavor analysis by comparison with unirradiated controls. A triangle taste test was used *(2)*. Acceptability evaluations were made by the hedonic scale method *(6)*.

Results. The triangle taste tests with the cereal bars indicated that no significant flavor difference could be detected when these were irradiated at levels below 200,000 rep (Table 1). The acceptability results (Table 2) indicate that no significant changes occurred at irradiation levels below 1.0 million rep.

TABLE 1

Triangle difference tests on irradiated and unirradiated cereal ration bars

Dose ($\times 10^{-5}$ rep)	Correct separations [1]	Significance of difference
0.7	10	Not significant at 5% level
1.0	10	Not significant at 5% level
1.2	9	Not significant at 5% level
1.9	10	Not significant at 5% level
2.0	12	$p < 5.0\%$
2.1	11	$p < 5.0\%$
5.0	15	$p < 0.1\%$
10.0	13	$p < 1.0\%$
15.0	16	$p < 0.1\%$

[1] Twenty judges total.

TABLE 2

Hedonic scale method evaluation test on irradiated and unirradiated cereal ration bars

Dose ($\times 10^{-5}$ rep)	Score	Stand. dev.	Significance of difference between scores	Percent of judges disliking bars
Control	5.6	1.6	Not significant	20
0.7	5.8	1.2	at 5% level	20
Control	4.8	1.5	Not significant	30
1.0	4.6	1.3	at 5% level	40
Control	5.8	1.6	Not significant	11
1.2	5.4	1.8	at 5% level	33
Control	4.8	1.5	Not significant	50
1.9	5.3	1.8	at 5% level	40
Control	6.3	1.4	Not significant	15
2.0	5.8	1.4	at 5% level	25
Control	5.7	1.8	Not significant	27
2.1	4.0	1.2	at 5% level	54
Control	5.4	1.8	Not significant	33
5.0	4.3	2.2	at 5% level	60
Control	5.2	1.5	Significant	38
10.0	3.7	1.7	at 5% level	70
Control	4.8	1.3	Significant	31
15.0	3.1	1.9	at 5% level	81

The panel was able to detect a significant difference in the flavor of brownies prepared from a mix irradiated with 105,000 rep, but the acceptability score of the irradiated samples was not significantly different from that of the unirradiated control.

The taste panel found the irradiated gingerbread both significantly different in flavor and significantly unacceptable. However, this appeared to be based on a difference in texture, which was poor in the case of the irradiated sample. By adding normal portions of baking soda and baking powder to the irradiated mix before preparation, the leavening was improved and this fault was corrected. The panel was then unable to detect any difference in flavor and judged the irradiated sample to be as acceptable as the unirradiated control.

It may be concluded that irradiation at levels at or below 100,000 rep will not affect the flavor of the ration components studied.

EFFECT OF CATHODE RAYS ON PACKAGED, INSECT-INFESTED RATION COMPONENTS

Experimental. To test the hypothesis that insects could be exterminated in packaged, insect-infested ration components by irradiation at a level that would not induce unacceptable flavor changes in the food and would not impair the functional properties of the packaging material, the following experiments were carried out. Commercial gingerbread mix was heavily inoculated with eggs and larvae of *T. confusum* and repackaged in cellophane bags. A cereal ration bar formula was also prepared and heavily inoculated with eggs and larvae of the same test insect. Bars were then formed, further inoculated with larvae, and finally wrapped in waxed paper. Some samples of the gingerbread mix and of the cereal bars were segregated as controls, and the remainder were irradiated at 105,000 rep. Both controls and irradiated samples were then stored under conditions optimum for growth of the insects (78° F. and 50% relative humidity). The gingerbread mix was examined after 6 weeks and the cereal bars after 3 weeks.

Results. With both the gingerbread mix and the cereal bars, many insects were found in the unirradiated samples but no growth whatsoever in any of the irradiated samples. It may be concluded that complete insect extermination can be achieved in some packaged ration components if they are irradiated at a level of at least 105,000 rep. The same results would doubtless be observed in other ration components if inoculated with insects and given a similar treatment.

SPECIFICATIONS FOR A PROCESS FOR DESTRUCTION, BY IONIZING RADIATIONS, OF INSECTS IN RATION COMPONENTS

As the experimental results reported in the earlier sections of this paper indicate the feasibility of destroying insects in packaged military rations without adverse side reactions, it is desirable to set up specifications for a process of insect eradication by ionizing radiations based on today's knowledge in this field and on certain necessary assumptions. The factors to be considered in the establishment of such specifications are enumerated in Table 3.

Space does not permit a detailed analysis of decisions that would be reached in the consideration of these factors, but the resultant choices made for the radiation sterilization of a typical ration component and a conservative cost analysis of such a sterilization process are summarized in Tables 4 and 5.

The main factors that should be considered with respect to radiological safety aspects in any program of this type are listed in Table 6.

SUMMARY

The general objective of this investigation was to determine whether insects in their several forms and of

TABLE 3

Factors to be considered in setting specifications for any radiation sterilization process

1. Type of radiation to be used
2. Estimation of dose required
3. Relation between applied dose and acceptability
4. Choice of packaging materials
5. Physical absorption in product—geometry of absorber and thickness (gm./cm.^{2})
6. Radiological safety program
7. Integration of above into cost of process

TABLE 4

Factors chosen for radiation sterilization of a typical ration component

Factor No.	Choice
1	Cathode rays (electrons) 1.85 m.e.v. by double bombardment
2	Dose = 50,000 rep (0.465 joule per gram)
3	Satisfactory acceptability
4	Packaging material = any conventional film, laminated film or foil
5	Product = fruit bar (1.50 gm./cm.^{2})

TABLE 5

Conservative cost analysis of radiation sterilization of a typical ration component

Assumptions:
1. Two accelerators (one spare) producing 2 m.e.v. cathode rays and operating at 1.85 m.e.v. and 250 μA
2. Amortization of initial investment over 5 years
3. 2,000 operating hours per year

Factors:

	Annual Cost
2 accelerators at $56,200 each	$22,480
Building modifications and shielding (estimated at $50,000)	10,000
Power cost 20,000 kw. hr. at 1c per kw.-hr.	200
Replacement parts	10,500
Personnel, three at $7,500 per year	22,500
Health safety and contingency	15,000
Total yearly cost	$80,680

Throughput per hour at 1.85 m.e.v. and 250 μA (462 watts) (50% efficiency) ..... 3,940 lb.

Throughput per year ..... 7,880,000 lb.

$$\therefore \text{Cost per pound} = \frac{\$80,680.00}{7,880,000 \text{ lb.}} = 1.02¢ \text{ per lb.}$$

∴ Cost per fruit bar ..... 0.08¢ per bar

TABLE 6

Radiological safety program

Factors to be considered
(a) Shielding calculations.
(b) Radiation survey. Measurements to be made with accelerator operating at full power, to ascertain whether shielding requirements are adequate.
(c) Continuous radiation monitoring. To insure no prolonged increase in area radiation because of operational difficulties, such as the cathode ray beam striking the inside of the accelerator tube walls, etc.
(d) Personnel monitoring. Film badges and personnel ionization chambers.
(e) Safety interlocks and warning lights. To prevent any one from entering a "hot" area with the generator operating.
(f) Medical examinations. Blood tests.
(g) Personnel training. Indoctrination in radiation safety.

different species could be eradicated, by irradiation, from selected military ration components (basically cereals and fruits) without affecting the physical and functional characteristics of the protective materials in which the foods were packaged and without affecting the acceptability of the foods themselves. If this could be accomplished, a further objective was to determine the economic feasibility of the irradiation process.

From comparative studies with reference to insect species and forms, packaging materials, ration components, and sources of radiation, it appears that eradication of insects in packaged military rations can be accomplished economically by irradiation with cathode rays, without affecting adversely either the acceptability of the food products or the physical and functional characteristics of the packaging materials.

Acknowledgments

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Most of the test insects were obtained from Mr. B. R. Wilson, entomologist of the Chemicals and Plastics Division at the Philadelphia laboratories of the Office of the Quartermaster General. In addition, a culture of *T. confusum* and a culture of *O. surinamensis* were received from Professor A. E. Michelbacher of the University of California.

The packaging materials and the cereal and fruit bars were sent to M. I. T. from the Quartermaster Food and Container Institute for the Armed Forces. Appreciation is expressed for this assistance.

Appreciation is also expressed to Prof. J. G. Trump and Mr. K. A. Wright of the Department of Electrical Engineering, M. I. T., for permission to use the Van de Graaff electrostatic generator in their laboratory; to Dr. Sol Davison of our Department for his measurements of the density of the ration bars; and to Mrs. M. C. Merritt and Mrs. E. H. Long, also of our Department, for assistance in the flavor and acceptability tests with the ration components.

LITERATURE CITED

1. Aikawa, Y. Some applications of the electric hygrometer in food packaging technology. (S. M. Thesis, Dept. Food Tech., Mass. Inst. Tech., 1953.)
2. Helm, E., and Trolle, B. Selection of a taste panel. *Wallerstein Lab. Commun.*, **9**, 181 (1946).
3. Landrock, A. H., and Proctor, B. E. Gas permeabilities of films. *Modern Packaging*, **25** (10), 131+, 199+ (1952).
4. Landrock, A. H., and Proctor, B. E. The simultaneous measurement of oxygen and carbon dioxide permeabilities of packaging materials. *TAPPI*, **35**, 241 (1952).
5. Lavers, C. G. Grease resistance. *Modern Packaging*, **21** (7), 147 (1948).
6. Peryam, D. R., and Girardot, N. F. Advanced taste-test method. *Food Eng.*, **24** (7), 58+, 194 (1952).
7. Proctor, B. E., and Goldblith, S. A. Quart. Progress Rept. on AEC Contract AT (30-1)-1164 for Jan. 1, 1952-March 31,1952. NYO 3338.
8. Proctor, B. E., and Goldblith, S. A. Tech. Rept. No. 3, Pt. 1, on AEC Contract AT (30-1)-1164, Sept. 1, 1952. NYO 3339.
9. Proctor, B. E., Lockhart, E. E., and Goldblith, S. A. The application of electronic treatments to destruction of insects in packaged military rations and packaging materials. Final Rept. for June 17, 1952 through Dec. 31, 1953 on Contract DA 11-009-QM-19888 with QM Food & Container Inst. for Armed Forces (1954).
10. TAPPI Standards, Method T 414/M-49.
11. TAPPI Standards, Method T 448/M-49. Tentative Standard Aug. 1940. Corrected Sept. 1949.
12. TAPPI Standards, Method T 454/M-44.
13. Trump, J. G., and Cloud, R. W. The production and characteristics of 3,000 kilovolt roentgen rays. *Am. J. Roentgenol. Radium Therapy*, **49**, 531 (1943).
14. Trump, J. G., and Van de Graaff, R. J. Irradiation of biological materials by high-energy roentgen rays and cathode rays. *J. Appl. Phys.*, **19**, 599 (1948).
15. Wink, D. A., and Van den Akker, J. A. Development of a method for the measurement of water-vapor permeability at low temperatures. *TAPPI*, **33**, 8 (1950).

Recent Advances Concerning the Stability of Foods[a,b]

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(Manuscript received July 10, 1954)

A few of the findings in recent years that have a direct or indirect bearing on several types of stability problems are reviewed. In particular, fundamental and applications researches pertaining to oxidative rancidity in fats and antioxidants are described. To a lesser extent, some of the recent developments pertaining to such areas as browning reactions, radiation sterilization of foods, and antibiotics in food preservation are described.

In its broadest sense, stability in foods means an ability to withstand changes in various perceptible and physiological properties, including odor, flavor, appearance, texture, and nutritive value. Deteriorative changes may occur in any or all of the major components of foods, i.e., carbohydrates, fats and proteins, and also in various minor organic constituents. The more important types of deterioration also involve one or more of the following: enzymes, microorganisms, reactions with atmospheric oxygen, reactions between two or more food components, and physical and physicochemical phenomena.

Approximately two-thirds of the technical articles that have appeared in FOOD TECHNOLOGY in the past year have been concerned directly or indirectly with some aspect of the stability of foods as defined in the foregoing paragraph. Perhaps this is not surprising; the field of food technology, after all, is concerned very largely with the processing of foods in such a way that their sensory appeal and nutritive value shall not deteriorate over such periods of time as may elapse before they are consumed. It is obvious that the stability of foods is a very big and broad subject, and that it is impossible to cover even a few selected areas adequately in a brief paper of this character.

Further, the areas in which the authors have firsthand knowledge and experience are necessarily quite limited. Special emphasis will be given, therefore, to an area with which they are most familiar; namely, the stability of the fat components of foods. In addition, a few other areas in which there is widespread general interest at the present time will be discussed briefly. These include browning reactions, radiation sterilization, and antibiotics in food preservation. No attempt will be made to cover each of these completely. In general, although there have been a number of developments in each area, the authors will consider only a few developments that have come to their attention more or less accidentally, with the object that these shall serve as points of departure for the discussion that will follow.

Before leaving this introduction, it should be pointed out that, as in other fields of scientific endeavor, the recent advances concerning the stability of foods are in no small measure attributable to the development of new analytical tools and techniques. The application of new chemical methods, and of ultraviolet and infrared spectrophotometry and radioactive tracers to problems in food stability is a voluminous story in itself, and could well serve as subjects for a comprehensive and useful treatise.

FAT RANCIDITY

In general, there are only two things that can happen to food fats under ordinary conditions. They may hydrolyze, or they may oxidize. The former reaction leads to a form of deterioration that is important particularly in some dairy products. Off flavors and odors result from the liberation of short chain fatty acids that are components of milk fats. Some advances have been made in the last few years in fundamental areas related to hydrolytic rancidity, particularly as regards the nature of lipases; enzymes of this class are primarily responsible for the development of this type of deterioration. However, no major new solutions to the problems of hydrolytic rancidity in foods have been found.

In spite of many noteworthy advances, oxidative deterioration in fats caused by atmospheric oxygen continues to be a major problem. Twenty-five years ago it was generally felt that an almost complete solution to the problems of oxidative deterioration in fats merely awaited the finding of a single suitable antioxidant. Today, a number of antioxidants are available, the usefulness of which is unquestioned, but rancidity problems persist with many types of foods. Even though new processing methods and new antioxidants are being developed at an ever accelerating pace, it is entirely possible that 25 years hence the oxidative deterioration of fats will continue to be a problem with some foods.

The most troublesome form of oxidative deterioration is so-called common oxidative rancidity which occurs typically in such fat products as lard and shortenings, but occurs also under some circumstances in almost any type of food which contains any appreciable amount of fat. This type of rancidity is characterized initially by a rather sweet odor which becomes progressively more pungent and offensive as the oxidation progresses.

It has been a common belief until recently that oxidative deterioration of fats is important only in food substances that have relatively high fat contents. It is being found, however, that the oxidative deterioration of lipid materials is responsible for off-flavors and odors in an ever increasing circle of low-fat foods. Undesirable flavor changes in some frozen vegetables and other frozen foods, and more particularly in various dehydrated foods, appear to involve fat oxidation.

Most people object to oxidative rancidity only on the basis of flavor and odor. Almost no one in this country likes rancid flavors and odors, although in some countries certain food products are not considered wholly desirable until they have become thoroughly rancid. In recent years, however, there has been a growing awareness that oxidative rancidity is important also from the standpoint of its harmful nutritional and physiological effects. Studies in the last decade have shown conclusively that oxidative deterioration in fats leads to the destruction of fat soluble vitamins, essential fatty acids, and various other nutritive elements. In addition, oxidized fats have been found to exert direct toxicological effects of various types. Studies of direct toxicological effects, however, have been much too limited and should be pursued more vigorously.

One reason for stressing the importance of these harmful effects is that oxidative rancidity in food fats is far more prevalent than is generally recognized. In many food products the rancid flavor and odor are masked by other flavor and odor components so that the presence of rancidity is not realized. In other cases, the presence of oxidized fat is not detected because the more volatile rancid products have been dissipated by heat or other means. Probably most Americans eat appreciable quantities of rancid fat almost every day in some food or other.

It has long been known that oxidative rancidity involves

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[b] Presented at the Fourteenth Annual Meeting of the Institute of Food Technologists, July 1, 1954, Los Angeles, California.

some rather complex chemistry. For many years it has been known that a variety of aldehydes, ketones, and acids are responsible for the rancid flavors and odors. However, recent researches have revealed that the oxidation reactions are even more complex than had been usually supposed, and hence a general and easy solution to the problems of oxidative rancidity is not possible. In this discussion the results of researches on the fundamental nature of oxidative reactions will be considered first and then, secondly, consideration will be given to some of the practical developments toward the solution of rancidity problems in some types of fat-containing foods.

Not so long ago, it was definitely established that the initial products formed in the oxidation of unsaturated fatty acid esters are hydroperoxides and that these are formed by a free radical chain reaction mechanism *(9, 10, 11, 21, 22)*. The autocatalytic character of the rancidification reactions was found to be attributable to the catalytic effect of the peroxides themselves *(9, 10)*. In decomposing, fat peroxides generate free radicals which initiate new oxidation reaction chains. Each free radical formed by decomposition of a peroxide molecule causes the production of dozens or hundreds or perhaps even thousands of new peroxide molecules. It has also been established that the formation of peroxides, from which numerous secondary products are derived, can be catalyzed by various metals, light, photo-chemical pigments plus light, and even by enzymes such as lipoxidase. In some cases the catalysts accelerate the reaction by catalyzing peroxide decomposition, thereby generating more free radicals, but in other cases quite different and not wholly elucidated mechanisms are involved.

BASIC RESEARCHES ON FAT OXIDATIONS

Without going into detail, a few of the important basic findings of the last five years relative to the autoxidation of fats will be described:

a. It appears that there may be important differences in the oxidation of fatty acid esters of different degrees of unsaturation. In the case of oleates, significant proportions of some type of peroxide other than hydroperoxide may be formed even in the early stages of the reaction *(62)*. With more unsaturated fatty acid esters, peroxides other than hydroperoxides are formed in later stages of oxidation *(23)*, but these appear to be a result of various subsequent secondary reactions.

b. With unconjugated polyunsaturated fatty acids or esters, oxidation initially results almost completely in the formation of conjugated diene hydroperoxides *(7, 11, 49)*; early in the oxidation the conjugated dienes are primarily in the *cis, trans* configuration, but in later stages, probably as a result of subsequent isomerization reactions, considerable portions of *trans, trans* conjugated dienes are also formed *(13, 49)*.

c. It has also been established that the decomposition of some unsaturated fat hydroperoxides is a first order process at low concentrations, and a second order process at higher concentrations *(50)*. This finding is important in relation to the effectiveness of antioxidants in the initial stages of the oxidation reactions.

d. The mechanisms involved in the lipoxidase-catalyzed oxidations of fat are fundamentally different from those of ordinary autoxidation *(67)*. The former appears to be a typical enzyme reaction. The hydroperoxides formed in lipoxidase catalyzed oxidations are optically active whereas those formed in autoxidation are not *(48)*.

The activation energy for the lipoxidase-catalyzed oxidation is low compared with the activation energies of most other enzyme reactions. This means that lipoxidase is proportionately far more active than most other enzymes at lower temperatures. Thus, lipoxidase is markedly active even at the low temperatures employed in home freezers or commercial food lockers. Lipoxidase is present in various vegetable materials, notably legumes, but it remains to be determined whether this enzyme is responsible for any of the off flavors that develop in frozen vegetables.

e. Various investigators have reported that lipoxidases are present in animal tissues and therefore may be responsible for fat deterioration in meat products. Attempts by many other investigators to isolate lipoxidases from animal tissues have been unsuccessful, and more recent studies appear to have shown quite definitely that the principal catalysts responsible for accelerated oxidation of fats in meats are hematin compounds *(66)*. Perhaps these findings will lead to more concentrated and successful efforts to solve troublesome rancidity problems that still arise with some types of meat products.

f. Various photochemical pigments including chlorophyll and some carotenoids have been found to have very marked catalytic effects on the oxidation of fats in the presence of light *(32)*. The oxidative mechanisms again are different from those of autoxidation and are not appreciably retarded by phenolic antioxidants. The problem of photochemical catalysts merits more attention than it has received, particularly in these times when transparent packaging is popular for many products.

g. Other recent studies have employed the techniques of countercurrent distribution between immiscible solvents *(13, 23, 51)* and chromatography *(34)* to obtain new information about the complex variety of substances that are formed in fat oxidations. An adequate summary of these findings is not possible in this paper, but it may be said that fundamental studies of this character are slowly but surely leading to important knowledge about the structures and mechanisms of formation of the secondary products that are responsible for undesirable flavors and odors.

This list of recent findings concerning fundamental aspects of fat oxidation is by no means complete, but is sufficient to indicate that steady and important progress is being made.

ANTIOXIDANTS

With many food products, the problems of oxidative rancidity may be met, at least partly, by various processing and packaging techniques. By minimizing or preventing contact with atmospheric oxygen, or by preventing the introduction of, or eliminating, positive catalysts, or by altering the chemical character or composition of the fat, oxidation can be retarded. In general, however, no startling advances have been made in any of these approaches in recent years.

In general, the use of antioxidants to combat rancidity appears to be the most attractive and efficacious solution with many types of fat-containing foods.

In spite of the furor of recent years over chemical additives in foods, the usefulness of approved antioxidants can hardly be questioned. With any of the antioxidants that are in common use today, any adverse effects that have been demonstrated are far overshadowed by the extent to which they retard the destruction of important nutrients and prevent possible harmful physiological effects.

Within the past few years much new light has been shed on the mechanisms of antioxidation. It has been shown that polyphenolic compounds are effective because they are good free radical acceptors *(12)*. They break the oxidation reaction chains almost before the latter have a chance to get started. Anomalously, however, phenolic antioxidants also act as prooxidants during the initial stages of oxidation. Recent researches have indicated that this prooxidant effect is brought about by a catalytic effect of the antioxidant on the decomposition of peroxides. Thus, a higher concentration of free radicals is generated and more oxidation reaction chains get started. At the same time, however, the antioxidant also greatly shortens the reaction chain. The overall effect is a slight increase in the rate of oxidation during the induction period, but at the same time, the induction period is greatly lengthened.

Some types of antioxidants have been termed synergists. Synergism in antioxidation exists when the protective effect of a combination of two antioxidants is greater than the sum of the protective effects achieved by the use of each of the antioxidants alone. Generally, one of the two antioxidants is far less effective when used alone than the other, and in some instances may be virtually ineffective.

The mechanism of synergism has not been clarified completely and may almost be regarded as a controversial subject. Generally the compounds that fall in this class are hydroxy organic acids, but some inorganic acids and other types of compounds also are effective. A common attribute of almost all of the common synergistic antioxidants is that they are capable of forming complexes with ions of copper, iron, and other metals. Some research workers therefore attribute synergism by citric acid

and similar substances entirely to inactivation of prooxidant effects through complex formation with trace metals that are present adventitiously in fats and oils. It appears entirely possible, however, that there are other important mechanisms of synergism, but such mechanisms require further elucidation.

Recent years have seen the development of a number of antioxidants that are highly effective in food products that consist primarily of fat. Most of these antioxidants, such as the tocopherols, nordihydroguaiaretic acid, and propyl gallate, are phenolic in character. In a few instances, these antioxidants have been applied effectively in foods where the fat coexists with an aqueous phase and other components, but generally the application of phenolic antioxidants in such products has not been markedly successful. In some cases, a solution to the problem appears to lie in finding a suitable solvent whereby the antioxidant can be introduced primarily into the fatty portions of the food. In other cases, it is necessary to find some way of distributing the antioxidant through the food product to whatever extent may be needed without destroying the integrity or structure of the food product. Obviously, the problem of distributing an antioxidant throughout some types of food products will not be solved easily.

In some circumstances, the distribution of the antioxidants throughout the unprocessed food is easily achieved, but the manufacture or processing of the food product causes destruction of the antioxidant. This, for example, is the case with phenolic antioxidants in baked goods. A few years ago butylated hydroxy anisole (BHA) was introduced, primarily on the basis that its antioxidant effect is not readily destroyed in the baking process *(17, 18)*. Baked goods such as pie crusts and crackers made from shortening containing BHA are far more resistant to rancidity than when BHA is absent. It is not known whether this carry-through property is due simply to a survival of some BHA in the baking process, or whether the BHA is altered in some way during baking without destruction, and perhaps even with enhancement, of its antioxidant ability.

Because of the desire for the carry-through property as well as a marked antioxidant protection in shortenings and, further, because of the enhancement of antioxidant properties by inexpensive synergists such as citric acid, manufacturers of lard and shortenings that contain animal fats now tend to use combinations of several antioxidants, rather than a single antioxidant, in such products.

The carry-through property seems to be associated in general with so-called "hindered" phenols. Generally, in antioxidants of this character, there is only one free hydroxyl present, and, in addition, with those that have been found to be most effective, alkoxy and tertiary hydrocarbon radicals are attached to one or more points in the aromatic ring. The most recently adopted antioxidant in this class for food use is di-tertiary butyl para cresol *(37, 61)*. In preliminary studies, this antioxidant appears to be somewhat more effective than BHA in shortenings, but may be somewhat less effective than BHA in carry-through, although further evaluation of these points appears desirable using the purer product that has recently been made available by the manufacturers.

Citric and phosphoric acids, which are synergist type antioxidants, are not, unfortunately, appreciably soluble in fats. Isopropyl and stearyl citrates, and other mono citrate esters, have therefore recently been introduced *(27, 28, 42, 43, 68, 69)*. These are much more soluble than citric acid and are reported to be effective synergists or metal scavengers. They will probably find application in combination with other antioxidants.

In spite of these advances there is still much room for research toward better antioxidants and toward better methods of incorporating antioxidants in more complex types of food systems. In some cases problems of rancidity may be overcome through a judicious use of natural food substances. Thus, for example, it has been found recently that many of the common spices used in foods possess appreciable antioxidant properties *(15)*. Thus, the centuries-old use of spices to flavor foods also has sound scientific basis in preventing the development of undesirable flavors in foods in some cases.

A review of the more important developments in antioxidants in the past few years has recently been published *(37)*.

Another finding that is of considerable interest in connection with the application of antioxidants is that in some food products, notably meats and poultry, there is relatively little deterioration of fat in the interior porion of intact cuts *(52)*. It has been found in beef, pork, lamb, and turkeys stored at 0° C. that the destruction of unsaturated fat components is virtually negligible except in exposed surface areas, and that these become rancid far beyond the initial point of unacceptability, even when no oxidation has occurred in interior portions of the meat. In such cases it would appear that antioxidants could find considerable utility simply if a suitable method for applying the antioxidants to the exposed surface regions was found.

Various other studies have shown that antioxidants may find uses beyond the prevention of oxidative rancidity. Some antioxidants appear to serve as aids to color retention in foods. This has been found true for peppers, pork sausages, and other products in which color is an important factor. In those cases where fats are present, the protective effect may be associated with a prevention of fat oxidation; it is known that some types of pigments are rather easily destroyed in coupled oxidation reactions in oxidizing fats.

REVERSION

Up to this point the discussion of oxidative deterioration has centered entirely around common oxidative rancidity. Another very important type of oxidative deterioration in fats and fat-containing food products is commonly termed "flavor reversion." This has been defined as a type of oxidative deterioration that occurs with less oxidation than is required to produce true oxidative rancidity. It occurs typically in soybean oil and other oils that contain linolenic acid or more highly unsaturated acids. It has been found that the presence of fatty acids with 3 or more double bonds is particularly conducive to the development of reverted flavors and odors under the conditions to which foods are normally subjected.

The importance of more highly unsaturated fatty acids in reversion has been demonstrated by an experiment in which cottonseed oil (which contains no linolenic acid and is not normally subject to reversion) was interesterified with a small amount of linolenic acid *(19)*. The interesterified product after being permitted to oxidize slightly was identified by an expert taste panel as reverted soybean oil. It is also known now that alpha, beta unsaturated aldehydes, among other compounds, are responsible for reversion flavors.

BROWNING REACTIONS

Foods with such pleasant aromas and flavors as freshly roasted coffee, roast beef, fresh bread crust, and many others would be unattractive and unpalatable, were it not for browning reactions. Yet, to many food processors, the development of a brown discoloration during the processing and storage of a food is regarded as an undesirable change.

The food industry is concerned with three broad types of browning reactions. The most common type includes reactions of carbonyl compounds (aldehydes, ketones, and reducing sugars) with amino compounds (amines, amino acids, peptides, proteins). These are commonly known as Maillard reactions. A second type of browning occurs in the absence of amino compounds when polyhydroxycarbonyl compounds are heated at relatively high temperatures (>100° C.) and is called caramelization. Both acids and bases catalyze caramelization and under certain conditions browning of this type may occur easily even at low temperatures. The third type includes a group of oxidative reactions that convert polyphenols into polycarbonyl compounds. These oxidations may or may not be enzyme catalyzed.

Our remarks will be confined to the carbonyl-amino type of browning or Maillard reaction. The complexity of these reactions is indicated by the fact that 15 compounds have been detected in a glucose-aqueous ammonia solution *(33)*, and at least 24 in a glucose-glycine reaction mixture *(14)*. In a recent excellent review Hodge *(30)* has integrated the several isolated partial theories of browning and has outlined a mechanism for browning in sugar-amines systems based on the Amadori rearrangement of the reaction product of reducing sugars with amino compounds to a 1-amino-1-deoxy-2-ketose. Dehydration, fission, and further condensation of the enol form of this compound give brown polymers. Hodge classified the reactions involved according to the three stages of development:

I. Initial Stage (colorless; no absorption in near ultraviolet)
   A. Sugar-Amine condensation
   B. Amadori rearrangement
II. Intermediate Stage (colorless or yellow with strong absorption in near ultraviolet).
   C. Sugar dehydration
   D. Sugar fragmentation
   E. Amino acid degradation
III. Final Stage (highly colored)
   F. Aldol condensation
   G. Aldehyde-amine polymerization; formation of heterocyclic nitrogen compounds.

Because of the complexity of the Maillard reaction and a lack of knowledge of the fundamental mechanisms involved, its prevention is at present largely limited to the use of conditions which retard it. From a study of dried skim milk, defatted soybean meal, meat meal, ground oats and dehydrated potatoes, it has been concluded that high humidity and high temperatures are optimum conditions for browning *(29)*. Similarly, browning does not occur when dry milk is stored at 40° C., or lower, if the moisture content is below 4% *(59)*. Further, commercial dry milk with a moisture content usually less than 3%, when stored in containers that are not moisture proof, will invariably absorb moisture from the surrounding atmosphere and develop a brown discoloration.

Patton *(46)* studied a number of factors involved in the heat-induced browning of liquid skim milk. Casein and lactose were observed to be the principal reactants in the production of the brown color. The temperature range from 100 to 120° C. appeared critical; no appreciable discoloration was produced by heating for 1 hour at 100° C., but browning was readily evident in samples heated for 7.5 minutes at 120° C. The pH region 6.0-7.6 was also found to be of critical importance. A change of as little as 0.1 of a pH unit within this range produced a noticeable difference in color.

Although preheated skim milk showed no difference in color from untreated milk, small differences proportional to the extent of preheating were observed following a second heat treatment. The reaction sequence leading to the formation of brown pigment was begun during the first heat treatment and continued during later heating periods. It was also found that milk subjected to tryptic digestion browns less easily than undigested milk, and that acid or enzymatically digested casein browns less easily than intact casein in the presence of lactose, suggesting that intact casein may act as a stronger base than casein hydrolysates.

Legault, *et al. (39)* found that the rate of browning of dehydrated vegetables increased from 1 to 4 fold for each 2% increase in moisture content and 6 to 8 fold per 10° C. rise in storage temperature. The presence of sulfite gave some protection against browning. There was little difference in the rate of browning of air- and nitrogen-packed samples.

Browning can therefore be minimized mainly by avoiding high processing temperatures and, in the case of dehydrated products, by processing to low moisture content and avoiding high temperature storage.

Since this type of food deterioration requires the presence of both carbonyl and amino compounds, destruction or inactivation of one of these should prevent browning. Fermentation of raw egg white is common practice in the commercial preparation of dehydrated egg white. Changes in stability in unfermented egg white have been related to the presence of glucose *(60)*. Several investigators *(3, 6, 31, 36)* have shown that removal of glucose from egg white or whole eggs by bacterial or yeast fermentation prior to drying decreases the tendency toward undesirable changes in solubility, color, and flavor. Kline *et al. (35)* showed that removal of glucose from eggs by yeast fermentation improved the storage life of the dehydrated product and resulted in no unfavorable organoleptic changes or lowering of the baking quality of the product. More recently, Baldwin *et al. (4)* have described a process whereby glucose is removed from egg white by a glucose oxidase-catalase enzyme system. In the presence of oxygen and water, the glucose oxidase oxidizes glucose to gluconic acid and hydrogen peroxide. Catalase breaks down the hydrogen peroxide with the following net result:

$$2 \text{ glucose} + O_2 \xrightarrow[\text{catalase}]{\text{glucose oxidase}} 2 \text{ gluconic acid}$$

Tarr *(63)* showed that ribose is much more active than glucose in the Maillard reaction. About five times as much glucose as ribose is required to give the same degree of browning in fish. Ribose is formed post mortem in fish flesh from nucleic acids, ribotides, ribosides, and other ribose-containing compounds. A number of organisms are able to utilize ribose, and it may be possible to decrease browning in fish by removing ribose enzymatically.

RADIATION STERILIZATION

Since the discovery of x-rays 60 years ago man has dreamed of utilizing the bactericidal properties of ionizing radiations to arrive at sterilization without the use of heat. However, this goal was not approached until the recent development of particle accelerators and nuclear reactors. During the past 15 years it has been shown that sterilization of certain food products by ionizing radiations can be accomplished in the laboratory. Before a process can be developed for commercial use on a large scale, however, a number of factors must be considered, and many questions must be answered. In a review three years ago Proctor and Goldblith *(55)* discussed some of these problems, most of which remain at least partly unanswered today. These may be summarized as follows:

a. Type of radiation available
b. Dose required for sterilization
c. Packaging
d. Possible deleterious effects of radiations on foods
e. Economic considerations

From the standpoint of efficiency of production, penetration, and safety, only cathode rays from particle accelerators and possible gamma rays from nuclear reaction products appear suitable as sources of ionizing radiations for the sterilization of biological materials. Large quantities of radioactive fission products have been produced by the Atomic Energy Commission as by-products of the operation of nuclear reactors and atomic piles. A comprehensive research program for the purpose of finding practical applications for these so-called waste products has been initiated and as one part of this program the possibility of using these radioactive materials as sources of radiation for sterilization of foods is being investigated. In the meantime, however, these fission products are not available for commercial use and the only available sources of ionizing radiations are several types of cathode ray generators.

Doses required for the preservation of food depend on several factors. In general, the destruction of microorganisms by ionizing radiations follows a first order reaction and certain organisms are more resistant than others. Spore forming bacteria are more resistant than nonspore formers, and bacterial spores are more resistant than mold spores. The approximate doses required to produce various biological changes are shown in Figure 1, which is taken from a review by Nickerson *et al. (45)*. This figure shows that the energy required to inactivate enzymes is much greater than is necessary to destroy bacteria. While crystalline yeast dehydrogenase is apparently easily inactivated by small x-ray doses, the enzyme is protected from destruction by much higher doses if glutathione is present *(5)*. Many other enzymes, particularly when present in their natural state in foods are far more resistant. The

catalase of *Micrococcus pyogenes* var. *aureus* is not completely inactivated by cathode ray doses that are lethal to the organism *(54)*. Frozen milk subjected to a 10,000,000 rep cathode ray dose still retains appreciable phosphatase activity. It appears that in cases where destruction of enzymes is necessary for food preservation, means other than high energy radiations should be considered.

Any process to be considered for food sterilization should be able to destroy spores of *Clostridium botulinum*. According to Proctor *(55)* this requires a dose of approximately 2,000,000 rep.

Salmonella organisms in whole egg mixtures were completely destroyed by cathode ray irradiation. The doses varied from 125,000 to 300,000 rep depending on the species of Salmonella present *(58)*. Aerobic or anaerobic, mesophilic and thermophilic bacteria in dry food products such as sugar, flour, starch, spices, and whole milk powder were completely destroyed by cathode ray doses of 1.33×10^6 rep *(57)*.

However, with some foods, irradiation can be used for food preservation at levels appreciably lower than those required for complete sterilization. The storage life of fresh fish fillets at 36 to 40° F. was considerably lengthened by irradiation of the fillets with relatively low doses of cathode rays *(44)* and insects in grain products may be destroyed by doses as low as 100,000 rep *(45)*.

To be useful, of course, the radiations must penetrate the product to be sterilized. The penetration of cathode rays into matter of unit density is approximately 1 cm. for each 2 m.e.v. of accelerating voltage. Thus, the product to be treated must be kept relatively thin. The thickness of the samples can be increased if it can be subjected to crossfire from two beams or, in the case of solids, if it is turned over and passed through the beam a second time. Thus, with 3 m.e.v. rays the penetration into material of unit density is approximately 1 inch (2.54 cm.) when the material is exposed from two sides. The penetration of the rays is inversely proportional to the density of the material being irradiated. Thus, metal containers are to be avoided or, if necessary, they should be provided with aluminum tops and bottoms. Plastic films make ideal containers when they can be used.

One of the results of ionizing radiation is the formation of free radicals. Many of the reactions of such free radicals lead to products that result in undesirable flavor changes.

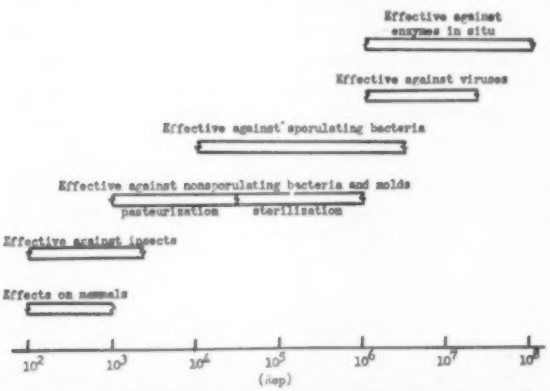

Figure 1. Dose levels of ionizing radiations required for various biological effects. (Nickerson, Proctor, and Goldblith, Am. J. Public Health 43, 554 [1953].)

Deterioration in flavor, odor, and color have been observed in many irradiated foods. It has been found also that under certain conditions appreciable amounts of amino acids *(53)* and certain vitamins *(16, 26)* are destroyed by ionizing radiations. Mead *(41)* has shown that the rate of autoxidation of linoleic acid is greatly increased by irradiation with x-rays and that it can be retarded by addition of antioxidants, particularly tocopherol *(47)*. Vitamin A, ascorbic acid, glutathione and cysteine were largely destroyed, but calciferol was not affected. In other cases ascorbic acid, niacin, and sodium sulfite have been able to act as free radical acceptors and greatly retard or prevent undesirable changes from taking place during irradiation of biological materials *(56)*.

From the economic standpoint several commercial cathode ray generators suitable for sterilization of certain foods are on the market at present. The price of the equipment increases rapidly with the accelerating voltage. The economic feasibility of sterilization by ionizing radiations will depend on such factors as initial costs, adaptability to present production methods, cost of operation, and other factors.

ANTIBIOTICS IN FOOD PRESERVATION

The use of antibiotics for the prevention of the deterioration of foods by microorganisms has been investigated during the past few years. Tarr, Southcott, and Bissett *(64)* reported that aureomycin in concentrations of 0.5 to 2 p.p.m. caused marked inhibition of spoilage of minced fish and meat stored at temperatures between 0° C. and 21° C. Terramycin and chloromycetin were also effective at somewhat higher concentrations while subtilin, penicillin, and streptomycin had little effect in concentrations up to 50 p.p.m. Rimocidin was effective in inhibiting yeast growth. Aureomycin was also effective when applied by dipping fish or beef steaks in solutions containing the antibiotic in 5 or 10 p.p.m. concentration. Bissett and Tarr *(8)* then showed that aureomycin and terracycin in minced fish flesh were easily destroyed by heating at 212° F. for 20 to 30 minutes. Sodium nitrite or ascorbic acid, two substances which have been used for fish preservation, had no appreciable effect on the stability of aureomycin. Spoilage of whole eviscerated fish was retarded markedly by ice containing 1 to 4 p.p.m. of aureomycin hydrochloride, by holding for 6 days at —1° C. in sea water containing 2 p.p.m., or by 1-minute immersion in solutions containing 50 or 100 p.p.m. of the antibiotic *(64)*. In 1950 Anderson and Michener *(2)* announced the complementary action of mild heat and the antibiotic subtilin. Cooking of peas, asparagus and corn at 212° F., or lower, for 10 to 20 minutes in presence of 10 to 20 p.p.m. subtitlin was sufficient to sterilize cans of these materials. Adams, Ayres, and Tischer *(1)* reported that subtilin decreased the spoilage of ground beef processed at 212 and 240° F. for periods up to 10 minutes. However, the level of antibiotic necessary for protection was quite high. In addition, there was some indication that the action of subtilin might be due to hindrance of spore

germination rather than to actual spore destruction.

Williams and Campbell *(71)*, however, were unable to prevent growth of a number of obligate and facultative thermophilic flat sour bacteria by using subtilin in combination with mild heat. Similarly Evans and Curran *(20)* reported consistent spoilage of milk inoculated with *Clostridium botulinum* and other commercially important microorganisms, and treated with subtilin and mild heat. They concluded that the subtilin-heat process was not safe or effective for preserving whole or concentrated milk. They reflected the view of Magdonelle *(40)* who had observed that the activity of subtilin was limited to a very few bacteria and that this antibiotic was not suitable for the preservation of foods.

More recently, however, Godkin and Cathcart *(24)* found that subtilin was effective in controlling the growth of food poisoning enterococci in custard fillings but that a combination of subtilin and terramycin was necessary to preserve the custard against experimentally added Salmonella bacteria. Deatherage and coworkers investigated the preservation of fresh meat by antibiotics and found that terramycin, aureomycin, and chloromycetin at 2.0 p.p.m. were effective in retarding spoilage in ground beef *(25)*. The same group later found that infusion of aureomycin into carcasses prevents spoilage of the meat when refrigeration is delayed. Aureomycin disappeared from the tissues in 72 hours *(70)*.

Finally LaBaw and Desrosier *(38)* found that a number of edible plant extracts contained antibacterial substances of varying degrees of activity. Several of these extracts were employed in conjunction with mild heat treatments as a means of reducing the heat tolerance of spores of food spoilage organisms. Since these compounds come from edible plants (carrots, beans, onions, and other common vegetables) they may be more easily accepted than antibiotics. From our present knowledge of antibiotics their widespread use in food preservation is uncertain. Recent research indicates that their usefulness may be limited largely to increasing the stability of fresh foods stored at refrigeration temperatures.

LITERATURE CITED

1. Adams, A. T., Ayres, J. C., and Tischer, R. G. *Food Technol.*, **5**, 82 (1951).
2. Anderson, A. A., and Michener, H. D. *Food Technol.*, **4**, 188 (1950).
3. Ayres, J. C., and Stewart, G. F. *Food Technol.*, **1**, 519 (1947).
4. Baldwin, R. R., Campbell, H. A., Thiessen, R., Jr., and Lorant, G. J. *Food Technol.*, **7**, 275 (1953).
5. Barron, E. S. G., and Johnson, Phyllis. *Arch. Biochem. Biophys.*, **48**, 149 (1954).
6. Bate-Smith, E. C., and Hawthorne, J. R. *J. Soc. Chem. Ind.*, **64**, 299 (1945).
7. Bergstrom, S. *Arkiv. för Kemi, Mineralogi och Geologi*, **21A**, (14) 1 (1945).
8. Bissett, H. M., and Tarr, H. L. A. Fisheries Research Board Can., *Prog. Repts. No. 93*, 23 (1952).
9. Bolland, J. L. *Proc. Royal Soc.*, **A186**, 218 (1946).
10. Bolland, J. L., and Gee, G. *Trans. Faraday Soc.*, **42**, 236, 244 (1946).
11. Bolland, J. L., and Koch, H. P. *J. Chem. Soc.*, **1945**, 445.
12. Bolland, J. L., and ten Have, P. *Trans. Faraday Soc.*, **43**, 201 (1947).
13. Cannon, J. A., Zilch, K. T., Burket, S. C., and Dutton, H. J. *J. Am. Oil Chem. Soc.*, **29**, 447 (1952).
14. Chichester, C. O., Stadtman, F. H., and Mackinney, G. *J. Am. Chem. Soc.*, **74**, 3418 (1952).
15. Chipault, J. R., Mizuno, G. R., and Lundberg, W. O. *Food Research*, **17**, 46 (1952).
16. Corson, M., Goldblith, S. A., Proctor, B. E., Hogness, J. R., and Langham, W. H. *Arch. Biochem. Biophys.*, **33**, 263 (1951).
17. Dugan, L. R., Jr., Hoffert, E., Blumer, G. P., Dabkeiwicz, I., and Kraybill, H. R. *J. Am. Oil Chem. Soc.*, **28**, 493 (1951).
18. Dugan, L. R., Jr., Kraybill, H. R., Ireland, L., and Vibrans, F. C. *Food Technol.*, **4**, 457 (1950).
19. Dutton, H. J., Lancaster, C. R., Evans, C. D., and Cowan, J. C. *J. Am. Oil Chem. Soc.*, **28**, 115 (1951).
20. Evans, F. R., and Curran, H. R. *J. Dairy Sci.*, **35**, 1101 (1952).
21. Farmer, E. H., Koch, H. P., and Sutton, D. A. *J. Chem. Soc.*, **1943**, 541.
22. Farmer, E. H., and Sutton, D. A. *J. Chem. Soc.*, **1943**, 119.
23. Fugger, J., Zilch, K. T., Cannon, J. A., and Dutton, H. J. *J. Am. Chem. Soc.*, **73**, 2861 (1951).
24. Godkin, W. J., and Cathcart, W. H. *Food Technol.*, **7**, 282 (1953).
25. Goldberg, H. S., Weiser, H. H., and Deatherage, F. E. *Food Technol.*, **7**, 165 (1953).
26. Goldblith, S. A., Proctor, B. E., Hogness, J. R., and Langham, W. H. *J. Biol. Chem.*, **179**, 1163 (1949).
27. Gooding, C. M., Neal, R. H., and Valteich, H. W. (to Best Foods, Inc.), U. S. Patent 2,485,637 (Oct. 25, 1949).
28. Gooding, C. M., Valteich, H. W., and Neal, E. (administratrix of estate of Ralph H. Neal, deceased) (to Best Foods, Inc.), *Ibid.*, 2,485,638 (Oct. 25, 1949).
29. Hake, J. H. *Proc. W. Virginia Academy Sci.*, **22**, 59 (1950).
30. Hodge, John E. *J. Ag. Food Chem.*, **1**, 928 (1953).
31. Hawthorne, J. R., and Brooks, J. *J. Soc. Chem. Ind.*, **63**, 232 (1944).
32. Hendrickson, M. J. (Ph.D. Thesis, Univ. of Minn. 1948). Lundberg, W. O. *Oléagineux*, **4**, 85 (1949).
33. Hough, L., Jones, J. K. N., and Richards, E. L. *J. Chem. Soc.*, **1952**, 3854.
34. Khan, N. A., Lundberg, W. O., and Holman, R. T. *J. Am. Chem. Soc.*, **76**, 1779 (1954).
35. Kline, L., Hanson, Helen L., Sonoda, T. T., Gegg, Joan E., Ferney, R. E., and Lineweaver, Hans. *Food Technol.*, **5**, 323 (1951).
36. Kline, L., and Sonoda, T. T. *Ibid.*, **5**, 90 (1951).
37. Kraybill, H. R., and Dugan, L. R., Jr. *J. Ag. Food Chem.*, **2**, 81 (1954).
38. LaBaw, G. D., and Desrosier, N. W. *Food Research*, **18**, 186 (1953).
39. Legault, R. R., Hendel, C. E., Talburt, W. F., and Pool, M. F. *Food Technol.*, **5**, 417 (1951).
40. Magdonelle, F. L. *Compt. rend. soc. biol.*, **145**, 1876 (1951).
41. Mead, J. F. *Science*, **115**, 470 (1952).
42. Neal, R. H., Gooding, C. M., and Valteich, H. W. (to Best Foods, Inc.), U. S. Patent, 2,485,635 (Oct. 25, 1949).
43. Neal, R. H., Valteich, H. W., and Gooding, C. M. (to Best Foods, Inc.), *Ibid.*, 2,485,636 (Oct. 25, 1949).
44. Nickerson, J. T. R., Lockhart, E. E., Proctor, B. E., and Licciardello, J. J. *Food Technol.*, **8**, 32 (1954).
45. Nickerson, J. T. R., Proctor, B. E., and Goldblith, S. A. *Am. J. Public Health*, **43**, 554 (1953).
46. Patton, S. *J. Dairy Sci.*, **35**, 1053 (1952).
47. Polister, Barbara H., and Mead, J. F. *J. Ag. Food Chem.*, **2**, 199 (1954).
48. Privett, O. S., and Boyer, P. D. (Unpublished results).
49. Privett, O. S., Lundberg, W. O., Khan, N. A., Tolberg, W. E., and Wheeler, D. H. *J. Am. Oil Chem. Soc.*, **30**, 61 (1953).
50. Privett, O. S., Nickell, C., and Lundberg, W. O. (Paper in preparation.)
51. Privett, O. S., Nickell, C., Tolberg, W. E., Paschke, R. F., Wheeler, D. H., and Lundberg, W. O. *J. Am. Oil Chem. Soc.*, **31**, 23 (1954).
52. Privett, O. S., Pusch, F., and Lundberg, W. O. *Food Technol.* (In press.)
53. Proctor, B. E., and Bhatia, D. S. *Biochem. J.*, **51**, 535 (1952).
54. Proctor, B. E., Coleman, Margaret T., and Goldblith, S. A. *J. Bact.*, **63**, 337 (1952).
55. Proctor, B. E., and Goldblith, S. A. *Food Technol.*, **5**, 376 (1951).
56. Proctor, B. E., Goldblith, S. A., Bates, C. J., and Hammer, P. Olivia A. *Food Technol.*, **6**, 237 (1952).
57. Pretor, B. E., Goldblith, S. A., and Fram, H. *Food Research*, **15**, 490 (1950).
58. Proctor, B. E., Joslyn, R. P., Nickerson, J. T. R., and Lockhart, E. E. *Food Technol.*, **7**, 291 (1953).
59. Shipstead, H., and Tarassuk, N. P. *J. Ag. Food Chem.*, **1**, 613 (1953).
60. Stewart, G. F., and Kline, R. W. *Proc. Inst. Food Technol.*, 48 (1941).
61. Stillson, G. H. (to Gulf Research and Development Co.) U. S. Patent 2,428,745 (Oct. 7, 1947).
62. Swern, D., Coleman, J. E., Knight, H. B., Ricciuti, C., Willits, C. O., and Eddy, C. R. *J. Am. Chem. Soc.*, **75**, 3135 (1953).
63. Tarr, H. L. A. *Food Technol.*, **8**, 15 (1954).
64. Tarr, H. L. A., Boyd, J. W., and Bissett, H. M. *J. Ag. Food Chem.*, **2**, 352 (1954).
65. Tarr, H. L. A., Southcott, B. A., and Bissett, H. M. *Food Technol.*, **6**, 363 (1952).
66. Tappel, A. L. *Arch. Biochem. and Biophys.*, **44**, 378 (1953); *Food Research*, **18**, 104 (1953).
67. Tappel, A. L., Boyer, P. D., and Lundberg, W. O. *J. Biol. Chem.*, **199**, 267 (1952).
68. Valteich, H. W., Gooding, C. M., and Neal, E. (administratrix of estate of R. H. Neal, deceased) to Best Foods, Inc., U. S. Patent 2,485,639 (Oct. 25, 1949).
69. *Ibid.*, 2,485,640 (Oct. 25, 1949).
70. Weiser, H. H., Goldberg, H. S., Cahill, V. R., Kunkle, L. E., and Deatherage, F. E. *Food Technol.*, **7**, 495 (1953).
71. Williams, O. B., and Campbell, L. L., Jr. *Food Research*, **16**, 347 (1951).

Enzyme Regeneration in High Temperature - Short Time Sterilized Canned Foods[a]

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Increased demand by the consumer for a high quality product at a low cost has brought about many developments and improvements in unit processes and techniques. High temperature — short time sterilization techniques, for example, have not only speeded production but have also improved the quality of the sterilized canned food products. The use of high temperature-short time sterilization techniques has attracted attention to factors not previously given too much consideration in thermal processing. One of these is the inactivation and subsequent regeneration of enzymes.

It has long been recognized that enzyme activity has an adverse effect upon the quality of fruits and vegetables. Although a great deal of data has been reported on the inactivation of enzymes in dehydrated or frozen fruits and vegetables, only a limited amount of data has been reported on the inactivation of enzymes in canned fruits and vegetables. Joslyn and Sedky *(6)* reported that early attempts to can or bottle citrus juices were unsuccessful primarily because the amount of heat required to pasteurize the juice was not sufficient to inactivate the enzymes. As a result of enzyme activity there was a loss of flavor and a loss of cloud. It was necessary to heat to at least 180° F. for one minute to inactivate the enzymes and thus maintain the cloud in processed citrus juices.

Esselen *(5)* in reviewing the thermal inactivation of enzymes as related to heat processed canned food products, stated that it has been frequently assumed that the heat treatment given canned products to destroy microorganisms capable of causing bacterial spoilage was more than adequate to destroy enzymes. Esselen *(5)* further stated that although this assumption is undoubtedly true in the case of low-acid foods which require a relatively long process to destroy bacterial spores, it may not necessarily hold in the case of acid products such as fruits and pickles which usually are given a relatively short and mild heat treatment.

The phenomenon of regeneration of enzymes is not new; it had been noted by various investigators as early as 1901. These early investigations are adequately reviewed by Schwimmer *(10)*. For the most part the investigations on regeneration have been limited to the enzyme peroxidase. There were several reasons for this. First, most available information indicates that peroxidase is one of the most heat resistant of the enzymes normally encountered in fruits and vegetables. In addition, its presence is easily detected by a relatively simple test. For these two reasons the inactivation of peroxidase has been used extensively as an indicator of blanching or enzyme inactivation, especially in the fields of dehydration and freezing.

The regeneration of heat inactivated peroxidase has been studied by a number of investigators. Schwimmer *(10)* working with turnip juice found that regeneration was largely a function of the heating rate. Upon heating, an enzyme precipitate was formed. Factors essential for regeneration were found to exist both in the precipitate and in the supernatant liquid. When the two were separated, neither the precipitate nor supernatant fluid regenerated; but when they were combined, a regeneration of peroxidase occurred.

Reddi, Esselen and Fellers *(9)*, Kaplan, Esselen and Fellers *(7)*, and Nebesky, Esselen, Kaplan, and Fellers *(8)* have extensively investigated thermal destruction, regeneration, and stability of peroxidase in acid foods. These groups of investigators found that while peroxidase showed evidence of regeneration after it had been partially inactivated by heat, no evidence of regeneration was evident up to 20 hours after heating if the enzyme was inactivated initially.

Balls *(1, 2)*, has discussed the phenomenon of reactivation or regeneration of heat inactivated enzymes to their original state. Esselen *(5)* in summarizing states that the problem of destroying an enzyme by heat requires a consideration of the effect of heat upon proteins and their denaturation. The regeneration of heat inactivated enzymes has been attributed to a reversion of the denatured protein to its native state after heating and cooling. It would appear that the enzyme must be heated sufficiently to irreversibly denature its protein in order to prevent enzyme regeneration. The degree of heat inactivation necessary to prevent undesirable enzymic action in a heated or processed food is not known. In some cases a partial inactivation of the enzyme seems to be sufficient to prevent undesirable changes in the ultimate product such as some dehydrated and frozen foods. Balls *(2)* has pointed out that a very small degree of enzyme regeneration might lead to undesirable changes in a food product if given a long enough time to react.

As previously stated, it has been assumed generally that the long heat processes given low-acid foods are adequate to destroy enzymes. However, with the introduction of the high temperature-short time principle of sterilization, employing the agitating type retort or flash sterilization in conjunction with aseptic canning, the problem of enzyme inactivation and subsequent regeneration became an important factor in determining processing time.

During the years which saw the development of short time-high temperature techniques in the heating and sterilization of canned foods, a number of observations

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were made concerning the peculiar behavior of the quality of the canned products *(4)*. Although, at the time, the causes seemed remote, the bulk of the evidence now available certainly indicates that the changes noted were the result of enzyme activity. For example, when flash sterilization temperatures normally employed (180°-190° F.) were insufficient to prevent enzyme activity, it was found necessary—in some cases—to raise the temperatures to as high as 240° F. to effect complete enzyme inactivity. Although the rise in temperature was substantial and more than adequate to destroy spoilage organisms, it did not adversely affect the flavor.

In some of the early test packs of canned whole kernel corn processed at high temperatures for short times, it was noted that the general quality of the corn after processing was exceptionally good, but that an off-flavor tended to develop as the storage period was lengthened. To eliminate the off-flavor development it was necessary to increase the sterilization value of the process by increasing the time at a given temperature. Similar observations were made in test packs of several Chinese-type foods.

The Research Division, Continental Can Company Inc. *(4)*, evaluated the use of the high temperature-short time principle for canned peas. The processing temperatures used were 280° F., 300° F., and 320° F. The times at these temperatures were such that the calculated sterilization values were well above those necessary for sterilization. However, it was noted that off-flavors and odors developed in most variables. The off-flavor was described as the typical strawlike off-flavor normally associated with underblanched frozen peas. An examination showed catalase and peroxidase activity in nearly all variables. As a result of these findings an investigation was undertaken to study enzyme inactivation and possible regeneration in canned peas processed in a high temperature-short time agitating retort.

PROCEDURE

For this investigation freshly shelled sweet type peas were washed, water blanched at 190° F. for 3 minutes and cooled. The peas were filled manually into enameled 202 x 214 cans and boiling brine was added just before the cans were closed. The cans were then processed for various lengths of time to calculated sterilizing values in an agitating-type retort at 260° F. and in a still-type retort at 250° F. and 240° F. The agitating type processes were carried out in a laboratory model, end-over-end retort. The still processes were carried out in thermal death time units, since with these units it was possible to bring the temperature to the desired point almost immediately and to cool very rapidly following processing.

The peroxidase activity was determined on the raw peas, both before and after blanching, on each processed variable within 2 hours after processing, and at intervals after several months' storage at room temperature. The method used was one developed by Balls *(3)* and modified for this investigation. It consisted of the conventional test adapted for quantitative measurements using hydrogen peroxide and guaiacol. The method is as follows: A slurry consisting of 50 g. of peas and 200 g. of water together with a filter aid was blended and filtered with suction. A one ml. portion was placed in a photometer cell containing 9 ml. of water and another one ml. portion was placed in a matching photometer cell containing 4 ml. of water. In a separate test tube, a solution consisting of 4.7 ml. of water, 0.1 ml. of a 0.1% guaiacol solution and 0.2 ml. of a 0.9% hydrogen peroxide solution prepared daily was mixed. This solution was added to the photometer cell containing the 5 ml. of water-pea slurry solution previously mentioned. The contents were mixed and the activity measured as optical density development per unit of time.

RESULTS AND DISCUSSION

The results of the peroxidase activity determinations and flavor tests are presented in Figures 1-4 and Table 1. The symbol F_o, i.e. the equivalent sterilizing value of the process in terms of minutes at 250° F., is used in these figures as a means of comparing processes. Most commercial processes for peas in small can sizes are based on an F_o value of 8. Although a number of the variables included in this investigation fall considerably below this value, they serve the purpose of comparison; namely, between theoretical bacterial destruction data and a possible curve for enzyme inactivation.

There was no detectable enzyme activity immediately after blanching. All canned variables were checked within 2 hours after processing and no peroxidase activity was noted. All variables were again tested for peroxidase activity 24 hours after processing. One variable processed at 260° F. in an agitating retort for 3 minutes, F_o 5.4 (Figure 1) showed a fraction of 1% of its original activity. In all subsequent examinations this variable showed activity at approximately the same level.

After one and two weeks storage, variables processed in an agitating retort at 260° F. to calculated F_o values

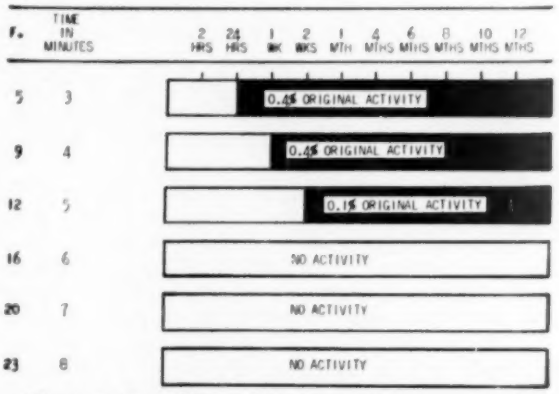

Figure 1. Peroxidase activity in canned peas processed at 260° F. in an end over end agitating retort.

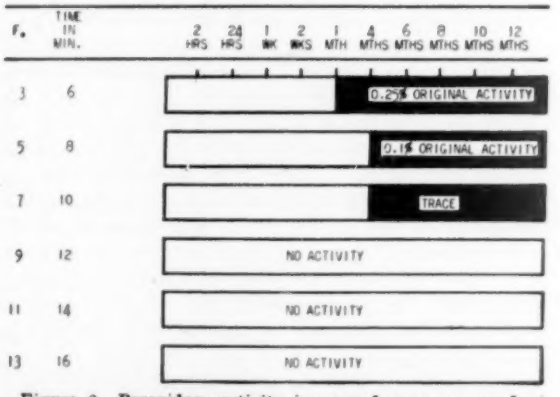

Figure 2. Peroxidase activity in canned peas processed at 250° F. in a still type retort.

of 9.0 and 12.6, respectively, showed evidence of peroxidase activity. The activity level in the variable with F_o 9.0 was similar to that found in the variable with F_o 5.4 and remained at approximately the same level. The activity in the variable with F_o 12.6 was not as pronounced as the other variable noted above.

As is shown in Figure 2, peroxidase activity was detected in several variables processed in a still retort at 250° F. However, it should be noted that in this case, where regeneration occurred, that the processes are below those recommended for peas.

As is shown in Figure 3, no enzyme activity was detected in any of the variable processed in a still retort at 240° F., even though a majority of the variables fell short of the recommended process time at this temperature. (The data presented in Figure 4 are a summary of the data included in Figures 1, 2 and 3.)

After 8 months' storage all variables were taste tested. Results of these taste tests are presented in Table 1. These results show that those variables which had continually showed evidence of peroxidase activity throughout the studies had a very definite viny-type off-flavor. Some of the variables which had lower levels of activity were judged to have a slight viny-type off-flavor.

The data presented seem to indicate that thermal inactivation of enzymes in processed peas do not follow the same type of curve as that for the thermal destruction of microorganisms. The majority of the variables

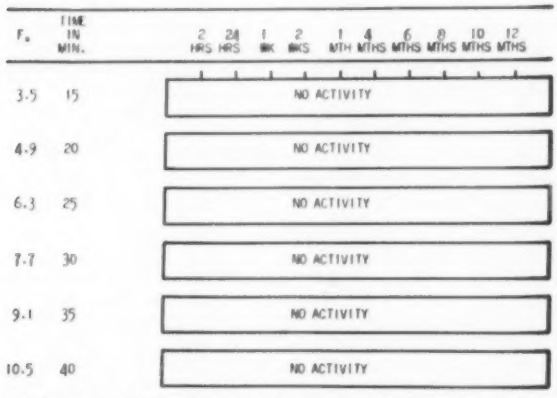

Figure 3. Peroxidase activity in canned peas processed at 240° F. in a still type retort.

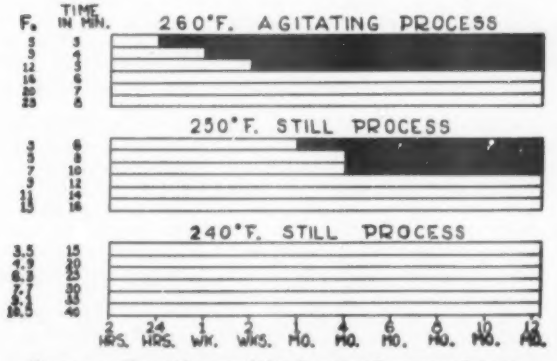

Figure 4. Peroxidase activity in canned processed peas.

TABLE 1

Peroxidase activity and flavor of canned peas stored at room temperature for eight months

Sterilizing value F_o	Process time in minutes	Percent of original peroxidase activity	Flavor
260° F. Agitating Process			
5	3	0.4	Very Viny Off-Flavor
9	4	0.4	Very Viny Off-Flavor
12	5	0.1	Slight Viny Off-Flavor
16	6	0	No Off-Flavor
20	7	0	No Off-Flavor
23	8	0	No Off-Flavor
250° F. Still Process			
3	6	0.25	Very Viny Off-Flavor
5	8	0.1	Slight Viny Off-Flavor
7	10	Trace	No Off-Flavor
9	12	0	No Off-Flavor
11	14	0	No Off-Flavor
13	16	0	No Off-Flavor
240° F. Still Process			
3.5	15	0	No Off-Flavor
4.9	20	0	No Off-Flavor
6.3	25	0	No Off-Flavor
7.7	30	0	No Off-Flavor
9.1	35	0	No Off-Flavor
10.5	40	0	No Off-Flavor

processed at 240° F. were given processes below that recommended for peas; yet no peroxidase activity was noted in any of these variables. It would appear that under these conditions the time and temperature were adequate to inactivate the enzyme. On the other hand, enzyme activity was noted in variables of F_o value 9 and 12 when the peas were processed at 260° F. in an agitating type retort. These results would seem to indicate that the curve of destruction of peroxidase in canned peas is much flatter or less steep than that effective for bacterial destruction.

CONCLUSIONS

As previously stated the many improvements and developments which have been made in processing techniques have not only speeded production, but have also improved the quality of the sterilized canned food products. By application both experimentally and commercially, high temperature-short time processes have been shown to have definite quality and nutritive preserving benefits for many natural and formulated food products. The time-temperature relationships used in specific applications are determined mainly by the time-temperature requirements for the destruction of spoilage bacteria. The main objectives of these studies, as reported, are to bring forth a limited number of observations which clearly show that enzyme regeneration does occur and that the time-temperature relationship for high temperature processes must be clearly established for complete enzyme destruction in some products to insure flavor stability. In instances where the enzyme regeneration problem exists, longer times of heating must be used to meet enzyme destruction requirements. Fortunately one of the inherent advantages of high temperature-short time processing is that this additional amount of heat may be applied in a very short time which from a practical standpoint, should encourage the broad application of the short time-high temperature principle for the advantages, particularly qualitywise, which may be obtained for many products.

LITERATURE CITED

1. Balls, A. K. The fate of enzymes in processed foods. *Fruit Prod. Jour.*, **22**, 36-39 (1942).
2. Balls, A. K. Control of enzymatic action in foods. *Proc. Inst. Food Tech. 1943*, 165-169 (1943).
3. Balls, A. K. (Personal communication.)
4. Continental Can Company, Inc. Research Division (unpublished data).
5. Esselen, W. B. Jr. Thermal inactivation of fruit enzymes in relation to processed products. *The Glass Packer*, **29**, 483-485 (1950).
6. Joslyn, M. A., and Sedky, A. Effect of heating on the clearing of citrus juices. *Food Research*, **5**, 223-232 (1940).
7. Kaplan, A. M., Esselen, W. B. Jr., and Fellers, C. R. Enzyme systems of canned acid foods: effect of processing conditions of time and temperature. *Ind. Eng. Chem.*, **41**, 2017-2020 (1949).
8. Nebesky, E. A., Esselen, W. B. Jr., Kaplan, A. M., and Fellers, C. R. Thermal destruction and stability of peroxidase in acid foods. *Food Research*, **15**, 114-124 (1950).
9. Reddi, R. R., Esselen, W. B. Jr., and Fellers, C. R. Peroxidase activity in apple tissue. *Food Technol.*, **4**, 63-68 (1949).
10. Schwimmer, S. Regeneration of heat inactivated peroxidase. *J. Biol. Chem.*, **154**, 487-495 (1944).

Engineering Aspects of Food Preparation in the Canning Industry[a]

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Although the term "food preparation" can be broadly construed to include all the manufacturing steps involved in producing the finished commodity, we shall construe the term in a more limited sense; namely, as it is used in the canning industry to describe operations by which raw products are made ready for canning. These are essentially the operations done at home when the same products are brought in from the garden or orchard and made ready for the table. And, as every housewife knows, cooking the foods may consume time, but their *preparation for cooking* involves most of the labor.

In a cannery the problem is basically the same. Although engineering and technology have made tremendous strides, preparation still demands the lion's share of cannery labor. We shall comment later upon the results of these important advances in mechanization, but lest we be carried away in our enthusiasm for them, it should be pointed out that the direct cost of hand labor in preparing fruits for canning constitutes from 30 to 70% of the total labor cost of the whole canning operation. This cost increment for hand labor in vegetable preparation is somewhat less, percentagewise, but still very substantial. Since both of these canning operations are multimillion dollar industries, the challenge to the engineers and technologists to further mechanize them is a vast and important one, not only to the food industry but to the public.

CONTRIBUTIONS OF THE PAST

Perhaps the best way to evaluate some of the more important preparation machines now available is to consider where we might be without them.

Twenty-five years ago, when the pitting of cling peaches was done by hand, this operation cost about $4.20 per ton at the then prevailing wage of 33½¢ per hour. If pitting were still done by hand, at today's wage of $1.32 per hour, the cost of this operation alone would amount to over $20 per ton. Instead, with mechanical peach pitters and mechanized handling, it is done for about $5.00 per ton, because the out-turn per worker is about four times as high as that of the hand operation. In the preparation of pears, a similar situation prevails. Obviously preparation costs will be further reduced for both of these items when automatic feeding devices for these machines are perfected.

These are developments of great interest to the public as well as to canners. With the tremendous increase in cannery wages in recent years many of our canned foods would have become luxuries rather than staples were it not for the part that engineering has played in eliminating hand work in cannery food preparation.

We have spoken only of the direct contribution that automatic preparation machinery has made to the economy of canning by reducing the amount of hand labor. The effect of these developments is much more far-reaching than that. They have also enormously increased production. In most canneries today it would be utterly impossible either to secure, or to provide adequate facilities to use, the hand labor that current production would require without these machines. Not many years ago a plant that turned out 20,000 cases in 24 hours was outstanding. Today there are a number which exceed 100,000 cases.

As one would expect, the greatest progress toward mechanization has been made in those operations which permit the products to be handled in bulk. At the present time nearly all fruits and vegetables destined for canning are washed and graded for size in fully automatic machines. Many are likewise peeled, cored or pitted, or divested of husks, shells, stems or other inedible parts by machines, totally or partly automatic.

Most of the hand labor now used in the preparation of fruits and vegetables for canning goes to the performance of operations which require the units of product to be individually handled.

Such operations include the hand feeding of fruits into semi-automatic machines whose successful functioning requires the fruits to be carefully oriented. Typical machines having such a requirement are peach pitters, pear peelers, tomato corers and the Ginaca machines which are used to prepare pineapples for canning.

The preparation of pineapple for canning is a highly efficient operation which has benefited greatly by good engineering. In most of the modern pineapple canneries hand labor is largely limited to sorting, trimming and the removal of deep eyes, seeds,

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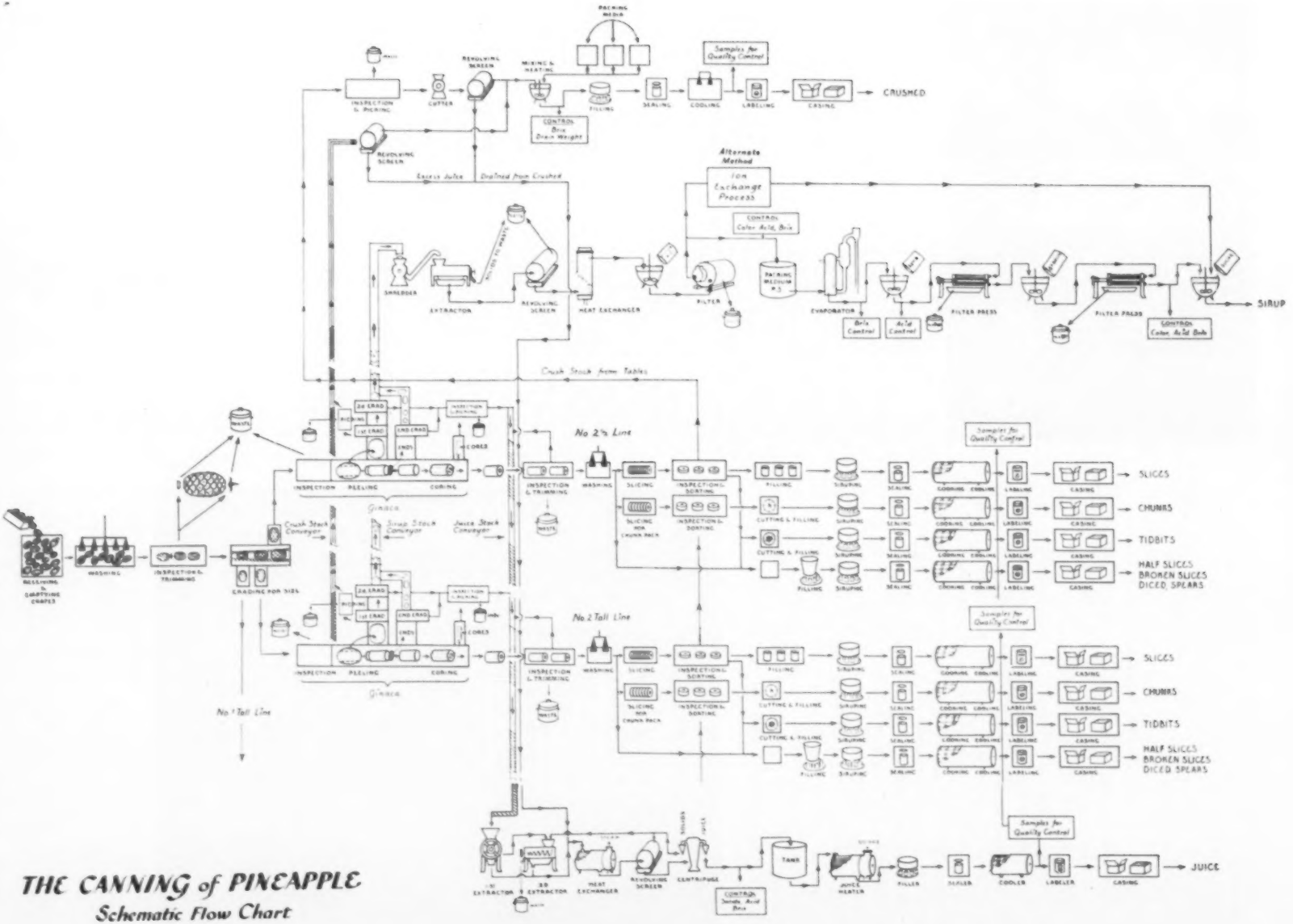


THE CANNING of PINEAPPLE

Schematic Flow Chart

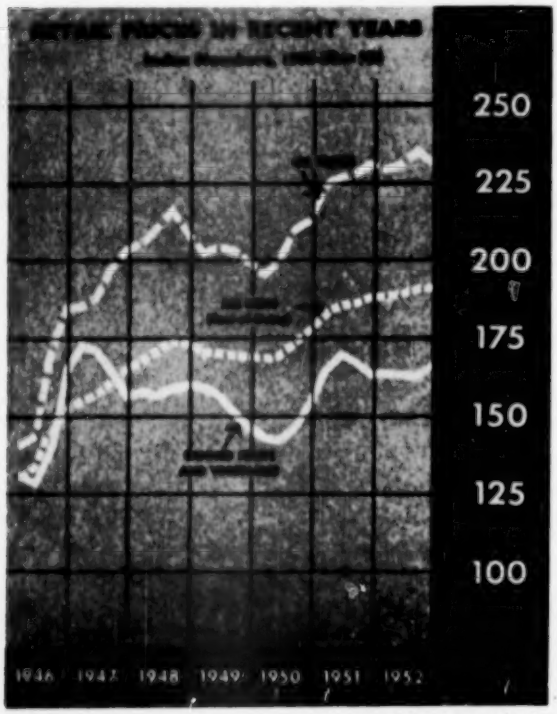
etc. Slices are still placed in the cans by hand, but this is because they must be handled for sorting, and pending the development of automatic sorters, little would be gained by mechanizing the filling of slices. The preparation of crushed pineapple and juice is conducted through a sequence of mechanized operations which require relatively little labor.

FUTURE TRENDS

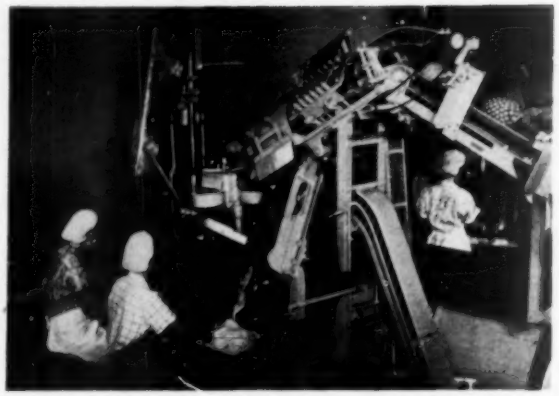
What can be said of future trends in the mechanization of food preparation?

While the hand-fed machines which have been mentioned have made a tremendous contribution to the economy of food preparation, in many cases their potential capacity has not been reached because of the slow and costly task of feeding the product into the machines by hand. Present labor costs offer an attractive field for engineering effort to be directed toward the development of automatic feeding devices for these machines.

Another and even more challenging assignment for the engineer lies in the development of machines to replace vistual inspection and sorting of fruits and vegetables. Good progress has been made in the automatic grading of such commodities as peas and beans which exhibit appreciable differences of density as they reach varying degrees of maturity. Density differences have also been utilized as a basis for automatic separation by flotation of foreign materials such as stones, thistle buds, etc. from peas and beans, once a tedious and costly hand operation.



These curves, based on U. S. Department of Labor statistics for the period 1946-52, show the retail prices of canned fruits and vegetables, the cost-of-living index and the prices for all foods, related to 1935-39 price indices of 100. The curve for canned fruits and vegetables shows quite strikingly that despite the tremendous increase in the hourly cost of cannery labor, the price of canned goods has remained relatively stable during the postwar period. There is no reasonable doubt that mechanization of cannery operations, particularly in the field of preparation, played an important part in keeping the price of canned goods at lower levels than other foods and commodities during this period of sharply rising prices.



This picture shows a Ginaca machine, which is perhaps the most important engineering development involved in the canning of pineapple. In the upper right-hand side of the picture you will see that the fruit is carried by a chain conveyor to the centering mechanism which properly aligns the fruit for the cutting operations performed by the machine. These operations include the removal of the fibrous central portion ordinarily referred to as the "core" and also the external skin or covering of the pineapple. Since the fruit is characteristically barrel shaped, the cutting operation necessary to produce a cylinder leaves a very considerable amount of usable fruit adhering to the skin, particularly near the mid section of the fruit. This adherent pulp is used to make beverage juice and a considerable portion of the crushed pineapple. In addition to cutting a cored cylinder the Ginaca machine also performs the function of removing this pulp from the skins as they are removed from the fruit. The entire outer portion removed to make the cylinder is unrolled or flattened out and passed under knives which remove two successive layers of the pulp from the shell. Because of the structure of the fruit, some of the calices, or "eyes" as they are called, project far enough into the fruit to be included in the pulp taken off. Naturally the innermost or first eradicator cut contains a minimum of these inedible parts and is, therefore, used for crushed pineapple. The girls you see sitting at the left side of the machine are there to remove these deep eyes or any other undesirable portions which may be found in the crushed stock as it passes out of the Ginaca machine. Such material present in the juice stock is removed mainly by mechanical means. Screens and centrifuges are used in this instance. The skins or shells are by now reduced to approximately ¼-inch thickness but still retain some edible pulp attached to their surfaces. This is recovered by a light pressing of the entire shell to yield a juice suitable after a sequence of refining operations to be used as a packing medium for canned pineapple.

In a vastly greater number of cases, however, visual inspection and hand separation remains the basis for product classification and the final removal of inedible portions and foreign material not removable by washing. Hope for the mechanization of these operations seems to lie in the field of electronics.

Substantial progress has been made in the development of electronic devices which will objectively classify fruits and vegetables on the basis of increments of color difference much smaller than the human eye can detect. This far the problem seems deceptively simple. However, much development work must be done before such devices can be used extensively to replace visual sorting operations in the cannery.

Present progress in the matter permits some fairly definite predictions concerning developments in this phase of mechanized food preparation. When such machines are perfected the upper limit of their capacity

will definitely be based on the mechanical rather than the electronic functions of the devices. A wide variety of other machines in which similar electronic functions are performed clearly indicate that there may be effected at speeds fantastically exceeding the rate at which discreet units of fruits or vegetables could ever be passed consecutively through a machine.

In fact, one might be safe in saying at this time that the future of electronic sorting machinery in the canning business rests mainly on the performance and cost of the product-handling elements of the machine.

This fact is graphically illustrated by the electronic color-sorting machine for lemons recently described by Powers and Associates of the University of California Department of Agricultural Engineering *(1)*. This device, which successfully classifies lemons into several maturity grades, has been shown to have the amazing potential speed of 100 units per second for its electronic "brain." Probably not more than 20 to 30% of this capacity is likely to be attained by the mechanical elements of the device which must bring the lemons individually to the scanning head and subsequently divide them into the various classes according to their color differences. Here indeed it is the "eye" that is quicker than the "hand"; but, notwithstanding this disparity, this device promises to be a noteworthy contribution to mechanized food handling. It is to be hoped that similar devices will soon be developed for sorting many fruits and vegetables in preparation for canning.

Assuming a successful solution of this problem, automatic trimming for blemishes, etc. may well be the next step. Such machinery will necessarily be intricate and highly specific in function. Therefore, it will not come directly as a by-product of engineering development in other industries.

The transition from hand preparation to mechanical preparation of foods without sacrifice of quality control poses many problems in the specialized branch of engineering now generally classed as "instrumentation." In this field important strides have been made in recent years, mainly because of the exacting requirements of our rapidly expanding chemical industries. To a great extent, the canners' requirements for instrumentation can be satisfied with general purpose instruments of high precision and dependability which are now available in wide variety. Instruments are now obtainable for measuring and in many cases recording or controling, temperatures, pressures, liquid and gas flow, pH, density, viscosity, refractive index and even color of materials in process.

Industrial television, already applied in other industries, may well become a tool for implementing and centralizing quality control of goods in process in food plants. This might well prove to be one of the most useful industrial applications for color T.V. when and if it reaches the stage where industrial applications are feasible.

Recently, several other important innovations have appeared in the area that we have designated as "food preparation" in the cannery. They are brought into this category through the achievement of successful aseptic canning. Hence, they involve sterilization before canning through the use of steam heat or various forms of radiation. These newer projects, involving irradiation, are receiving a great deal of well-deserved attention. However, it appears reasonably clear that their use can be justified only when substantial product improvement can be achieved, since they are not likely to reduce or even equal the low cost of similar sterilization with steam or hot water.

A FINAL WORD

Therefore, we conclude that these innovations, fundamental and important as they are, do not alter our premise that in the canning industry, mechanization of food preparation still presents the most economically important area for engineering research and development, regardless of how final preservation of the product is effected. And this applies with almost equal force to the manufacture of packaged frozen food as well.

LITERATURE CITED

1. Powers, J. B., Gunn, J. T., and Jacob, F. C. Agricultural Engineering, Vol. 34, No. 3, P. 149-54, 158.

Engineering Aspects of Food Production Unit Processes[a]

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Over the past 50 years the disposable income per capita has doubled. In the last 25 years the cost of a low priced automobile has increased by four. In contrast, the proportion of income spent for food has remained relatively constant at approximately 25%. This relatively constant proportionate expenditure for food over a period of rising prices, expanding economy, and improved, if more expensive, nutrition is the resultant of the application of engineering methods to food production processes.

Technical developments during these 50 years have brought about revolutionary changes in transportation, communication, and similar fields. A parallel, and in some respects, even more remarkable development has taken place in the food and nutrition field. To the consumer, this development is most apparent in the contrast between the grocery store of his youth, and the modern supermarket. To the technologist, this advance may be highlighted by mentioning our present knowledge of the role of accessory food substances, and amino acids in human nutrition.

This recent knowledge of vitamins, amino acids, and of enzyme systems has resulted in pronounced improvement in nutrition; it is not fortuitous that insurance actuaries are presently revising life expectancy tables. Developments in nutrition theory have been matched step by step by advances in technology, from automatic appliances in the home, more efficient farm machinery through factory devices which are constantly being improved in terms of quality, sanitation, and reduction of unit costs of labor.

A photograph of an 1890 pea canning plant shows women and children shelling peas by hand into buckets. How many peas can an 8-year-old child shell in 10 hours? A cannery superintendent of that day could have told us; but today, whatever his answer, and whatever the low pay for the operation, the labor cost per can would be fantastic.

In comparison, a photograph of a modern plant would show nearly as many workers on a food preparation line, but two striking differences would be immediately apparent; there are no children, and the workers would not be shelling peas, pitting peaches, cutting corn, or whatever the operation, by hand. Instead, on a contemporary line, the worker would be tending a machine, feeding a machine, or inspecting the results of a machine operation. By contrast also, the entire plant and warehouse facilities of an early plant would scarcely suffice to accommodate the flat carton storage space of a modern establishment. This striking difference in volumetric productivity is the direct resultant of the application of machine methods to unit production processes.

An example may emphasize the striking change in unit production processes. The equipment per worker of the corn preparation line of an early plant consisted of a sharp knife and a bucket, representing an investment of perhaps a dollar and a half. Worker pay was about 15 cents per hour, and worker production averaged possibly 6 ears of corn per minute. Waste from the whole kernel production was high; indeed, it was the attempt to minimize this loss by scraping the cob with the dull side of the knife, that led to cream style corn, first known as Maine style corn.

Contrast this with the present situation. The investment in unit equipment per worker has increased 600 to 700 times; wages have risen tenfold, and production thirtyfold. When we consider that comparable changes have been effected in other related unit processes, from harvesting to warehousing, the very real revolution accomplished by application of machine operations to food processing can be visualized.

This mechanization of unit processes, and rise in both wages and capital investment per worker, provides an increasing incentive for development of higher operating speeds. For example, if the capacity of a filling machine can be doubled by an increase in capital investment of 20% and if there is a rise of 20% in taxes, maintenance, insurance and the worker's wage level, the cost per unit production is decreased to approximately six-tenths of the cost per unit on the slower speed machine. In our competitive economy, this decreased cost is soon passed to the consumer; in an era of inflation this benefit may not appear in the shelf price of an item, but the real value is found in the decreased ratio of consumer income required to purchase the item.

Present activity in mechanization of unit processes is broadly directed along four avenues; first, increase in operating speed of presently mechanized units; second, replacement of presently required manual labor by automatic equipment; and third, the integration of several unit processes into operating systems. An aseptic canning line, for instance, represents the integration of a number of unit processes into a complex operating system. Finally, and fourth, a consistent and continuing effort is being made to develop mechanical methods for hand harvest operations.

Machines do not spring into being in a state of full development. Each of today's many complex machines has a history beginning with the origination of an idea and leading by way of successive changes and improved designs to more efficient models. Each machine, in short, must be engineered. The consequent demand for engineering time is reflected by the ever growing number of engineers within the food industry. In 1939 about 1900 men were so employed; in 1950, approximately 6000. This growth of 315% is in contrast to an increase of 100% in the number of bacteriologists and chemists in this industry over the same period.

Four kinds of engineers are employed in the food

[a] Presented at the 14th Annual Meeting of IFT, Los Angeles, California, July 1, 1954.

industry; sales, applications, production, and development engineers. Everyone is familiar with sales engineers, and the task of the production engineer is also well known. This paper, then, is limited to the role of the development and application engineer.

DEVELOPMENT ENGINEERING

Sterilization. In the early days of the food processing industry, relatively simple development work sufficed to meet the demand for increased production. As an example of the increasing complexity of engineering skill requirements, we may outline developments in the most basic and universal unit process in the canning industry—sterilization; in engineering terms, a problem in heat transfer. The initial development in this field used a boiling water bath to sterilize sealed containers. As spoilage was experienced, the process time was increased until some plants were processing 5 hours or more.

When the inadequacy of boiling water as a sterilizing medium became apparent, calcium chloride was added to the bath, and the temperature thus increased; this increased sterilization effectiveness, but caused the build-up of steam pressure within the containers. The results were sometimes spectacular, in the way of bursting containers, and leakage, a new source of spoilage. Heavy-walled containers were tried, but at this time the steam pressure treatment, the retort process, was found to be successful, providing not only a reliable sterilization method, but also removing a "bottle neck" from plant operation. Production processing rates immediately increased, but can cooling now became a major problem. This situation was eased by the development of the relatively simple cooling canal, which in turn, allowed more efficient use of both processing equipment and labor.

Cooling. The next development was the continuous cooker, and its correlative, the continuous cooler. In contrast to the simple engineering needed for the cooling canal, the continuous cooler required engineering to much closer limits. As higher processing temperatures, and increased speeds were used, the simple open cooler became inadequate and, to avoid buckling, a more complicated "split-cooler" was developed to operate in conjunction with the continuous cooker.

The most recent advance in can cooling techniques is the Micro-cooler. This represents an increase in technical and engineering complexity, but results in a reduction in operational complexity and in floor space requirements. This development resulted from a detailed investigation of the dynamic pressure changes within a container with reference to noncondensable and condensable vapors in the can headspace.

The engineer of the Micro-cooler must know not only basic heat transfer theory, but must command an accurate, detailed knowledge of the internal pressure variations within a container over time intervals of the order of one one-hundredths of a second. He must understand the flow characteristics of steam at sonic velocities, and the effect of varying pressures in the flow pattern of a water distribution system. Operating conditions must be anticipated to accommodate varying container types and sizes according to process requirements. It is apparent, therefore, that a sizeable portion of the cost of this item of equipment reflects the engineering costs incurred in its development.

Progress in processing equipment. This brief account of progress in the unit processes of sterilizing and cooking is typical of the development pattern of most items of processing equipment. The attainment of higher operating speeds and greater efficiency has been expensive; as the easy simple improvements have bene made, each increment of improvement has represented increased demands upon engineering „kills and applied research.

The attainment of increased efficiency and higher capacity of processing equipment has led to the development of highly specialized machines. Certain machines, as corn huskers, may be useful for only one product. Other machines, as continuous cookers, which result in pronounced labor saving over retort operation, are designed to handle an increasing range of container sizes and to be flexible with respect to speed of operation and process temperatures; this flexibility permits diversification of products, an acute problem in a seasonal industry.

The manufacturer of processing equipment at any one time is confronted with a number of possible development programs. And as the processor must reckon with high labor costs, so the manufacturer must consider costs in evaluating possible development programs. Obviously, to remain in business, a manufacturer must make a profit. The first question to be answered about a proposed development then is, "Is the equipment needed?" The next most important factor to be considered in development evaluation is the size of the potential market. Briefly, when the machinery manufacturer can amortize his design, development, and production costs over a greater number of units, the cost per unit to the purchaser drops accordingly.

Engineering skill and experience— frequently summarized in the term "know-how" is an important resource of the manufacturer and must be wisely expended. Thus a third factor in the choice of development programs is the availability of suitable skills in the engineering department.

Having determined that an item of equipment is needed, that a potential market of sufficient size to repay development cost exists, and that engineering resources and talents are available, a more detailed study of the development is made. As this point the general form of the ultimate machine begins to appear, and the operating speed and number of functioning units must be selected with reference to the average size of the unit operation to be replaced by the new installation. Finally, the sales price of the ultimate machine is estimated, and compared with the value of the proposed operation. This estimate is an order of magnitude esttimate only, but it is of great importance. If the projected selling price is markedly larger than the value of the completed machine to the potential customer, further development is hazardous.

If the foregoing analysis proves favorable, a development program is started. Normally this proceeds by way of the design and construction of working models of the functional units which might be employed in the final machine. From tests of these models the engineer selects that which seems best suited to the requirements, and builds a test machine or pilot model. This model is usually of lower production capacity than the final commercial machine, but includes all of its salient features. The pilot model is then field tested, sometimes for several seasons, and improvements are incorporated. When performance specifications are met, the critical features of the pilot machine are embodied in the design of a commercial, production model machine. The task of the development engineer normally ends here as production engineering starts.

It can be seen from this brief discussion that, not infrequently, a machine developed for a small market bears a price to the customer in which a dominant factor is the development cost.

This "hidden value" in a machine is not, in most cases, apparent to the purchaser, and the tendency on his part is to value a machine as, roughly, so many hours of labor, plus so many pounds of metal. It must be emphasized that the principal value of a machine to the purchaser lies in the job it does, and an efficient, well functioning machine is efficient, and functions well almost in proportion to the research and development expended upon it.

Unfortunately, once a new machine, representing perhaps many thousands of dollars and months of time in development, and constituting a marked advance over previous models, is marketed, the manufacturer cannot then relax and enjoy the fruits of his "venture" capital invested in the development. Commonly a new machine, especially if utilizing some new principle of operation, serves to spur competing groups to intensify their efforts and, at best, only a limited time is available to recover the investment.

The patent system of the United States has been established in recognition of this situation and a patent supposedly provides a period of 17 years in which the development costs can be amortized. In attaining patent protection for specific claims, one is apt to define a function which, by ingenious engineers, can be attained by other routes. Although patent protection is desirable and is usually sought, the issuance of a patent by no means frees the manufacturer from the necessity for continued efforts in research and development.

APPLICATION ENGINEERING

The application engineer differs from the development engineer in that he is concerned with function rather than with method. For example, in considering a corn cutting machine,

the development engineer is interested in the principle of the cutting operation and in details of machine construction and operation. The application engineer views this machine as a functioning unit. He is not concerned with how the corn is cut, but that from so much corn per minute the machine will produce so much cut corn and so many cobs. His task, with reference to this example, is to fit this cutter into an integrated series of operations leading from unhusked corn in bins, to canned, processed corn in the warehouse.

In addition to his main task, the application engineer commonly initiates a considerable proportion of development projects. He also, usually in cooperation with the development engineer, conducts field tests on pilot machines. Further, he must analyze production costs and, in connection with selection of equipment for specific functions, he must balance investment, operating, and labor costs of a proposed installation against the return to the processor if the installation is made.

A manufacturer of processing equipment rarely receives in the mail an order for a filling machine, or a continuous cooker or any major item of equipment. Indeed, even though technically trained salesmen or sales engineers, make routine calls upon processors, it is seldom that a major item of equipment is directly sold on such calls. Basically, this is because a processor does not buy a machine as an isolated item. Instead he buys equipment to fit into a complicated sequence of operations; the function in question can usually be filled by several alternate routes. Each processing plant differs from other plants more or less widely, even though the general operations for similar processes may be comparable.

The choice of the best solution to a processor's problem of selection of an item, or items, of equipment requires a knowledge of the characteristics of a wide range of processing machinery. Such factors as capital costs, labor charges, expansion plans, tax structures, plant space, and even such items as temperature of the local water supply and average humidity of the local air may require consideration in selection of equipment.

Each problem is analyzed by the application engineer with reference to the specific needs of the individual processor. While some processors may doubt this, a very serious effort is made to avoid "over-selling" a customer because it is poor policy to sell a machine and lose a customer. The application engineering department is one of the most important factors in securing and keeping the greatest asset of the manufacturer, the satisfied customer.

A case study. The range of activity of the application engineer is so complex and varied that his work can best be explained by example.

A sales engineer, calling upon a fruit processor, found that the purchase of a new syruper was under consideration to replace an existing machine which had reached the period of excessive maintenance. The sales engineer discussed the situation with the processor and sent to the application engineer a flow sheet of the existing line and a floor plan of the plant. This line, for processing peach halves, consisted of two gravity syrupers, two exhaust boxes, and two continuous open cookers with a 200 can per minute capacity. The processor wanted an increase to 250 cans per minute.

The application engineer, after studying this particular situation, recommended installation of a vacuum syruper, a steam flow closing machine, and a continuous pressure cooker. These items would replace the two gravity syrupers, the exhaust boxes, the two open cookers, and one closing machine.

The application engineer handling this problem prepared a detailed analysis of the processor's operation which demonstrated that the cost per case of product would be substantially lowered by the proposed installation. In this particular instance, a substantial sale of equipment resulted.

Not infrequently, however, the activity of the application engineer has for the immediate present a negative value to the manufacturer. A case in point occurred last spring when a California fruit processor requested a sales engineer to recommend a continuous cooker installation for his plant. This request was forwarded to the application engineering department which made an analysis of the processor's situation. In this case, the application engineer suggested only an increase in retort capacity and a larger filling machine. If, aided by this change, the business continued to expand, the application engineer suggested that in 3 to 5 years the processor would then be able to make economical use of a continuous cooker line.

Communication is one of the very difficult problems in a large manufacturing plant. Because the attention of the development engineer is focused upon his immediate problems, it is difficult for him to keep informed on trends and problems in processing plants. The application engineer, by the very nature of his work, must command a broad understanding of a wide variety of processing operations. Through his close contact with the sales engineer he is in constant touch with recent advances and problems in the industry. In consequence, many new developments, especially of the type designed to meet some immediate need of the processor, are initiated by the application engineer.

Testing. The application engineer has still a third function. When a new machine has been developed, it must be field tested. Basically two types of tests must be made. First, the machine must do the task for which it was designed—that is, it must stem cherries, pit peaches, juice oranges, or whatever. Second, it must fit into a process line, fit both functionally and economically. The application engineer has a wide and detailed knowledge of processing, both technically and with respect to economic factors. Hence, he must judge new developments with reference to economically sound integration in existing lines.

It is apparent that the application engineer occupies an important position in the relationship between the manufacturer and the processor. On the one hand he sees to it that improvements in processing equipment and methods are brought to the attention of the processor. He also sees to it that processing problems are referred to the appropriate agency of the manufacturer for solution. It is obvious that to offer intelligent advice regarding machine requirements and processing methods, the application engineer must have a detailed knowledge of the processor's operation. In some areas of operation this requires a knowledge of items usually held secret by the processor. The remarkable degree of confidence placed in the integrity of the manufacturer by the processor is illustrated by the fact that such information is nearly always made available.

In many cases a new machine must be tested in an actual processing line. In the course of the testing it is frequently necessary to speed the line up, or slow it down. Frequent shutdowns occur as adjustments are made. Detailed measurements and careful records of the operation may be required. Such tests, needless to say, tend to interfere with production.

Again the remarkable degree of cooperation existing between producer and manufacturer may be illustrated by our experience, when on many occasions we have operated—for a short time only to be sure—an entire processing plant in order to explore the range of operating conditions of a machine.

This cooperative relationship between the processor and manufacturer with respect to information and equipment testing is not a one way road. First, the manufacturer, and his agents, have an implicit responsibility to the producer to retain as confidential any information so given. Second, every effort should be made, and in practice is made, to avoid interference with production during machine testing. These obligations, so far as human frailities permit, are rigorously observed by the manufacturer. The benefits to the producer from this policy are considerable. First, technical developments and their application to specific processing problems are encouraged.

Secondly, new developments of mutual benefit to both manufacturer and processor are fostered. In most cases, such developments are supported by the manufacturer but, where a limited market, coupled with a real need, exists, a processor or a group of processors may support part or all of a development program. Such a relationship requires an attitude of mutual trust and respect.

Third, by means of the service of the application engineer, the processor has available for the solution to his problems the aggregate experience and technical knowledge of the entire industry.

CONCLUSION

You will recall our picture of an 1890 canning plant which showed a large number of women and children engaged in carrying out, with the aid of very simple equipment, unit process operations. A photograph of a

contemporary plant still shows a large number of workers, but with the difference that each operator is tending a machine, feeding a machine, or inspecting the result of a machine operation. What, we may ask, might a photograph taken 45 years from now show? We can certainly expect continuing transference of unit operations, now carried out by hand, to machine functions. But there is the beginning of a new type of mechanization which suggests that, in some types of processing, a photograph in 1999 will show aggregations of machines operated from complex control panels but tended by relatively few workers.

These developments, which are just starting, of selective sensing elements, coupled with the "feed-back" concept to control systems, opens, to our imaginations, the possibility of automatic or semi-automatic processing plants. If you object that this is speculative, why so it is, but so, once, was the concept of a mechanical corn cutter.

Engineering Aspects of Food Packaging[a]

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(Manuscript received July 1, 1954)

Packaging is defined as the preparation of goods for shipment. In the packaging field, we have many terms that seek to tie up *engineering* with *packaging*. Here are a few of them: *Packaging Engineering; Package Engineering; Packaging Engineer.*

Then we hear the term *Package Development*, by which is meant the act or art of producing the material and construction specifications for a package that will confer the degree of protection required by a product. The development man is occasionally a Food Technologist who is competent to state the problems in a quantitative manner which the package must solve. Sometimes he is a physicist, but more often, he is a Chemical Engineer.

In many food companies, the purchasing man is the whole works in packaging development and package procurement. But top management is remiss when it allows the purchasing man to have the whole say-so in packaging. I have queried upward of a hundred purchasing men on the following:

"If an order comes to you to procure a package for a food product and the order is not accompanied by enough specific data for you to proceed intelligently, have you nerve enough to fire it back to your principals and demand the indispensable data on which to proceed?"

To my amazement, I have found only two that have admitted that they have the requisite nerve to go back to their principals for adequate information about the packaging requirement of the food product to be packaged. Perhaps the others have the nerve but lack an understanding of the principle that a food package is developed to do a specific job in an economic manner.

Below are the basic concepts for a good package, whether it be for a food product or some other form of goods. (Food and chemical packaging present the most difficult problems of all packaging.)

1. Good food packages are developed to protect a specific food product. The universal, yet economic, package does not exist.
2. Good food packages are developed to protect the food against a finite set of conditions. The more varied the conditions to be met, the more expensive the package must become in order to meet all the varied conditions.
3. Good food packages are developed to protect the food for a finite period of time. It is too expensive to package for eternity, even if the food would remain edible that long. Of course, that word "eternity" may require a definition. I am using it in the sense of meaning an indefinite period of time, rather than "forever."

These principles place a responsiblity on the food company to have its packages as low-cost as possible for the conditions to be met. One must never forget that the cost of the empty package is often nearly as large as the cost of its contents. This fact should provide a stimulus for constant study of packages and new packaging methods, materials and machines. For, in a competitive economy, there is always the possibility that the competitor may be able to sell his equivalent product at a lower price, solely because he has learned how to package it a little cheaper, yet do it effectively.

Having briefly described the basic principles of a successful protective package, we should now describe the comparable principles of engineering. If there is any one attribute of an engineer that differentiates him from the scientist, it is his consciousness of cost. Engineering involves a habit or pattern of thought—as well as cost consciousness. A good engineering report ends up with a dollar sign and a figure. A hoary aphorism about engineering is that a good engineer can do for $1.00 what any damn fool can do for $3.00. And still another statement is that a good engineer can arrive at the correct conclusion without complete data. But, you can look in vain in the unabridged dictionary for anything even remotely resembling the preceding ideas.

Engineering seems to have many definitions and none of them are exact. This is true because engineering is an art—not an exact science. The engineer was originally a practitioner of the art of applying the principles of physics to solving a problem at hand. He is well aware that principles of physics are exact, but he is also aware that materials with which he must work in his application of physics are not exact or constant in their properties.

Military Engineering, the oldest form of the engineer-

[a] Presented at the 14th Annual Meeting of IFT, Los Angeles, California, July 1, 1954.

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ing art, later gave rise to Civil Engineering. In the early days of Civil Engineering, it was only the application of the principles of physics (chiefly mechanics) to civil life in contrast to military life. Other branches of engineering developed, first characterized by the application of physics alone. Later, they were characterized by the application of two or more sciences. Thus, we have Civil Engineering giving rise to Sanitary Engineering, and Mechanical Engineering giving rise to Chemical Engineering.

THE NEWEST OF THE ENGINEERING FIELDS

Today (1954), we are on the threshold of a further evolution of engineering, where it combines the practical application of three or more sciences. The sciences are physics, chemistry (including biochemistry) and microbiology, and their practical application I shall call Food Engineering.

Food engineering. Engineering of the package itself, always calls for the application of the principles of physics; it may frequently also call for the application of the principles of chemistry in the development of food packages; also, at times, it calls for microbiology; and occasionally, for biology when rodents and insects are involved. But in all cases, it calls for a broad gauge viewpoint and lots of engineering common sense. Engineering the food packaging *operation* calls for the application of all the foregoing sciences.

Engineering of the *package*, whether it be the unit package, an intermediate package, or the outer shipping container, is a vast subject. Just to illustrate the magnitude of the field of inquiry, consider corrugated fibre shipping containers. To a layman (in the packaging sense), the corrugated shipper is a simple package.

A tabulation of the major variables in corrugated containers reveals 10 major classifications, and many of these have from two to five sub-classifications which, if we calculate their possible permutations, make a minimum of about 383,000 kinds and shapes of possible shipping containers—all made out of paper, adhesives, and tape or staples. Obviously, the selection of the right container of this type for a given service should not be made by trial and error. It must be made by a systematic method. First the packaging requirements of the contents must be evaluated: size, shape, weight, protection of contents against shock damage, water vapor ingress or loss, grease resistance, materials-handling characteristics and the like. Then, the cost of inserting contents and sealing the filled container must be considered. Finally, a few sample containers are made up that are presumed to meet the foregoing packaging requirements. These are then tested in standard testing equipment, first with simulated contents and, perhaps later, with the commercial contents, just to see if the package will actually do what it has been calculated to do. The final step is to make actual test shipments. At any stage, it may be necessary to go back and re-study and re-design the shipping container and then again proceed with the tests before the container can be specified.

It is easy to over-package—to play safe by selecting a package that is far and away beyond the needs of the contents—but it will either cost too much, or cost far more than is economic.

There you have in an over-simplified form one form of package engineering. But there are other aspects of package engineering.

Packaging Problems That Involve Shipping Containers

Guaranteed annual wage. One of the industrial problems of the day is the continued insistence by organized labor for a guaranteed annual wage. While very few firms have yet contracted to guarantee to all workers an annual wage, the agitation for it continues. If it comes, it will bring with it a packaging problem of considerable magnitude. It will be in its most aggravated form in the seasonal food industries where production of the food raw material comes during a few weeks in the year but the period of distribution and consumption continues thoughout the entire year. In a slightly less aggravated form, the same packaging problem will occur in those industries where production is possible the year round but the consumption curve has seasonal peaks and valleys.

In both instances, the factory warehouse or the public warehouse must serve as a surge point or reservoir, and here is where the packaging problem is found.

Package or warehouse "fatigue." There is a packaging phenomenon variously called fatigue, package fatigue, or warehouse fatigue. Corrugated and solid fibre containers seem to lose their strength on long storage. It has been diagnosed as "fatigue" which, at the time, seemed to explain the situation and, by the use of a big word, it was possible to look wise and explain that the reason why a huge pile of cased goods toppled over in the warehouse was that the shipping cases had succumbed to "warehouse fatigue."

But, what caused the fatigue? The answer has been known only since about 1951 when the Forest Products Laboratories of USDA at Madison, Wisconsin, and Container Laboratories, Inc., in Chicago, became aware of the trouble and its cause. The cause of so-called fatigue of shipping containers is now known to be due to gradual absorption of moisture when the ambient air in the warehouse has a relative humidity of higher than 50-55%. The higher the R H, the more rapidly the fatigue phenomenon becomes apparent. The shipping cases begin to buckle at the bottom of the pile, of course, and, where the contents do not support the load (such as products in flexible containers), the piles will ultimately topple over. But where the contents of the fibre shipping containers are bottles or tin cans, the piles are more likely to remain upright even though the bottom and middle cases may buckle. This problem, of course, requires a solution. The time of storage may be shortened, the R H may be maintained below 50% by suitable air conditioning techniques, the piles may be kept low enough so that the "fatigued" shipping container still has enough residual strength to support the load, or a type of more expensive container may be employed that will have a much slower rate of absorption of moisture. If the relative humidity is maintained below 50% it is possible to stack the containers to a height equivalent to one-third the top-to-bottom compression test on properly sealed empty new containers, and the cases will stand up for any reasonable time that can be considered economic. If the R H remains above 60%, then the strength of the cases is so weakened that only 20% or less of the top-to-bottom compression test is safe. In the foregoing instances, the figures apply to the cases at the bottom of the pile where the stresses are greatest.

Warehouse design. Secondary applications of the preceding principles are found in design of warehouses, especially of new warehouses in areas where the cost of land is very high and every cubic foot of storage space should be utilized in the interest of economy. This sort of problem has arisen principally in recent years when the advent of the high-lift pallet truck makes it possible to lift goods to the top of high piles with very little cost for doing it. Obviously, there would be no point in building a warehouse with a 25-foot ceiling when the cases themselves would not justify a ceiling more than 15 feet high. There is no profit in empty space.

If the problem of guaranteeing an annual wage should ever face your company, be sure that the packaging aspects of the problem are not overlooked.

Tight cases minimize end and side damage to canned goods. In the engineering design of fibre shipping containers for canned goods, the problem of top-to-bottom strength is a matter of lesser moment than the end-to-end strength. The reason is that the contents will usually carry the load from top to bottom, but damage to contents can occur when the cases are subjected to endways or sideways shocks such as may occur when freight cars are "Humped" in marshalling yards. There is no safe rule to follow in meeting this problem, for humping damage varies greatly in different yards.

The partial general remedy for such end and side damage to contents of shipping cases is a very snug fitting case. In the past, the shipping cases have been too large. Recent experience shows that the case should have dimensions slightly smaller than the volume occupied by the contents. Where hand packing of cans into smaller cases is the practice, it is likely to lead to higher labor costs, but where automatic case loaders are used, the job is easily accomplished and the contents usually arrive at destination in better condition in tight cases than in loose cases.

Frozen food shipping containers. Still on the subject of the shipping container, we must not overlook the packaging prob-

lems that arise in the frozen foods field. Warehouse fatigue problems are not so severe here because the usual freezer warehouse does not often have the high ceilings that may be found in so-called dry storage warehouses. Hence, the goods are not normally piled to such great heights. Two pallets high is the maximum. But other problems exist and must be solved in one way or another.

One common problem that still exists is the condensation of moisture on cases removed from freezer storage and are below the dew-point of the ambient air. The amount of such moisture pick-up and the length of time of such exposure are both factors affecting the strength of the shipping case. In aggravated situations, the case may become too soft to hold its contents. If, however, the case is promptly placed back into freezing conditions, the condensed moisture will freeze, then sublime to the freezing units and ultimately become a problem for the refrigerating engineer. In this sort of problem, it is not good practice to select a shipping container that will resist moisture absorption because of the much greater hazard that exists in the possibility of the thawing of the frozen food. Speed of handling to minimize the exposure to unrefrigerated air is the preferred method of avoiding trouble and expense.

Typical Problems—Some Case Studies

1. A product is made in New Jersey. It is packaged in a laminated carton 14 x 20 x 16 inches, with adequate moisture barrier properties. Twenty-four cartons in a shipping container weigh 40 lb. They are shipped in straight car loads to New Orleans for "dry" storage for a maximum of 100 days. In the warehouse in New Orleans, they are to be stacked 14 cases high. *Problem:* What shall be the specifications of the board from which the shipping containers shall be made?

2. Fresh meat is to be wrapped loosely in either parchment or greaseproof paper and shipped by truck in corrugated shipping containers. Total elapsed time between packaging and removal to display cases in retail meat stores will be not over 60 hrs. *Problem:* What sort of material shall be specified for the inner liner of the shipping case?

Some food products enjoy an exceptional volume of sale at specific periods in the year, such as Christmas or Easter, although they may have a moderate sale throughout the remainder of the year. The normal procedure would be to manufacture the item at a fairly uniform rate and store it in a suitable warehouse, and sell against warehouse stocks. But this introduces packaging problems that must be solved in order to make it a success. If the product is one that must be protected from moisture gain or loss during storage for several months before it is distributed in the channels of trade, it may be necessary to wrap it in a packaging film possessing a low enough WVTR (water vapor transfer rate) to insure the product's freshness at the end of the storage period. Films of low WVTR usually cost more than those of higher WVTR. Yet not all of the year's production will need the extra shelf life. So it is possible to effect an economy by packaging a part of the production that will go into consumption promptly after shipment in the less expensive film.

Management must make the major decision as to the relative cost of the more expensive package produced at a uniform rate throughout the year versus the lower cost package produced in haste for only a part of the year. The decision is management's, not the packaging engineer's, but the packaging engineer must supply the data on which the decision must be based.

Packaging is done for a finite purpose, for a finite period of time, to meet a finite set of conditions. Industry cannot afford to package for infinity: it costs too much. And, except for a very few products, hermetically sealed in rigid, opaque containers and sterilized by heat, it is technologically impossible to package a food for indefinite periods of time. This brings up the question of how long is commercial "infinity," to which I propose a rather practical answer: Longer than it will pay to hold the product. Five or ten years would be an example of commercial infinity.

The universal package can be said to exist only in the form of the rigid metal container. Many an inexpensive food product cannot afford this package cost and remain in successful price competition with similar products packaged in the less expensive flexible containers, or in competition with other food products. But even flexible packages vary in cost depending upon their barrier properties. And smart food companies with nation-wide distribution take advantage of this fact and package their foods to meet the conditions that exist only in the area where they are sold. Thus, the larger companies where a complete knowledge of packaging is found will often use one package for products sold in warm, high-humidity areas and a different package for the dryer and cooler parts of the country. The economy per package may be only a few hundredths of a cent, but where millions of packages are involved, the savings are substantial. But, of course, such economies are feasible only where a system of merchandise control is in effect, and where the shipping containers are properly coded so that nobody inadvertently ships a northern package into the deep south.

LACK OF COMPREHENSION OF THE IMPORTANCE OF PACKAGING INTRODUCES PROBLEMS

It is difficult to make a clean cut line of demarcation between packaging and other aspects of food processing in respect to:

Overhead	Engineering
Purchasing	Materials Handling
Research	Sales and Sales Promotion

But on the production line it is simpler, though still not a completely sharp distinction between packaging and production. While we may say that, by definition, packaging starts where the product is first inserted into the unit package and ends with the shipping container sealed or closed and ready to move into the warehouse or shipping room or area, that definition is not wholly adequate. For immediately the question arises as to the act of supplying empty packages to the production line: is it packaging, or is it something else? The same question arises about closures, labels, glues, shipping containers, and the like. We need not go into detailed arguments as to what is or is not concerned with packaging at this point.

This minor confusion is cited here to point up one very pertinent truth that pervades, not only the entire food processing industry, but also all other industries that package their goods. Up to now, I have never known of any company that has anybody in charge of *all* aspects of packaging. To be sure, a few companies have a job known as "Coordinator of Packaging," but I do not believe such a job-title exists in any food processing establishment. You may well ask why I bring this up here. Here are my reasons:

1. Top management rarely understands packaging or all that the term really includes.
2. More than half the direct labor-hours in the *average* food plant are packaging labor-hours. The exact figures, as determined by a survey I once conducted, reveals that in 20 plants manufacturing and packaging 22 different foods from liquids to solids, from powders to lumps, in bottles, cans, cartons, bags and drums, the packaging labor-hours varied from a low of 26% to a high of 90%, with the arithmetical average at 59.4% of the total direct labor-hours.

If you are surprised at these figures, you ought to study the figures on consumer goods industries that produce cosmetics, toiletries, perfumes, petroleum products, drugs and pharmaceuticals, where figures run all the way up to higher than 90% in those industries that produce the product which they package and sell. In those industries that purchase their product in bulk, package and sell it, the entire direct labor force is engaged in packaging; hence, 100% of all their direct labor-hours are packaging labor hours. Even the food industry has at least one in the 100% category. Other food industries that come close to this figure are not common but they exist.

What is the significance of the finding that an average of more than one-half of direct-labor hours are employed in packaging? My own interpretations follow:

1. Very few people see the obvious, even when they walk through the plants where they are employed. For example, I was once asked to criticize an operation where I found:

   1 dough mixer
   1 oven man

22 women on the packaging line
1 man on the carton closing machine
1 man who packed the cartons into shipping containers and toted them away as well as brought up packaging supplies.

Out of *26* persons, *23* were engaged in packaging, which figures out slightly over 88%. The interesting feature to me was that the company was making a fair profit, due solely to the excellence of its product and its consequent ability to command a profitable price.

2. Packaging operations, though often highly mechanized, have not yet achieved the degree of mechanization or development that we find in the equipment used for producing the product to be packaged. There is a tremendous area for further improvement in engineering the packaging operations.
3. Management does not often see packaging in its true perspective and, hence, does not encourage the entire organization to realize where the pay roll is being chiefly spent. Packaging is often regarded as a sort of "necessary evid." I will admit the *necessity*, but not the *evil*.
4. Top management often holds unbalanced views of packaging, often disregarding all but the psychology of the appearance of the package. Top management often places, or allows, the responsibility for selection and development of its packages to rest on the purchasing man. Although he is often quite unprepared by technical training and experience for this duty, he does the best he can, aided often quite capably by technical service men from manufacturers of packaging supplies. But his education is gained on a trial and error basis and is one of the costliest educations one can imagine. I have known of episodes where it cost the company upward of $200,000 for a single such packaging lesson.

It is very common for food companies to spend years of research and development on a new food product without a single thought as to its packaging. At the next-to-last moment, the package is considered and, fortunately, in many instances the supplier may have the answer.

After the package has been selected (either with or without adequate study, development and testing), then the packaging machinery is thought about. Sometimes this is forgotten until the sales force is being primed on how to sell the new product. Then ensues a wild scramble to procure the required machinery which is seldom in stock, save in the case of the simpler, general-purpose machines.

Those of you who have had long experience in the canning field have had few problems of this sort, but those whose experience has been in the flexible packaging field where package dimensional standards are virtually non-existent are doubtless aware that special machines often have to be built. It takes many months to get delivery and still more months to work out the mechanical "bugs" that often exist in new machines operating on new packaging supplies for a new product.

ENGINEERING THE PACKAGING LINE AND EQUIPMENT

Examples of engineering aspects of plant operations involving food packaging are many. I can mention only a very few to illustrate several types of engineering problems encountered in packaging operations.

Vacuum Packaging

Two examples are given of engineering problems in vacuum packaging of foods: every food technologist is aware of the technological gains from packaging a food in a vacuum. There are many persons, however, who do not seem to realize that the principal virtue of a vacuum in a package is not the vacuum, *per se*, but the comparative absence of oxygen—the great enemy of flavor. In the laboratory, it is very easy to prove that many products retain good flavor longer in a vacuum package than in one where air is present in appreciable quantities.

The first example is that of a company that planned to package a product in cans to be evacuated to 29-inch vacuum. The production line was set up but after only a few hours of operation, it was pronounced a failure because no cans could be found that had more than 5 to 8 inches of vacuum instead of 28±. This represented removal of only about 2 to 3% of the oxygen and certainly was of no particular value in extending the shelf life of the food product. Actually, there was nothing wrong with the principle of vacuum packaging. The only trouble was with the engineering of the installations.

Too many people regard a vacuum as nothing—mere empty space—and seem to surmise that vacuum (empty space) can be piped in small pipes: that there is nothing there, so why not a small pipe diameter? Actually, vacuum is a gas, usually air or steam, at very reduced pressure—a highly attenuated gas. And, if it is true that it is almost nothing, it is also equally true that there is an awful lot of "nothing." Where vacuum piping is properly designed, the pipes are astonishingly large.

Going back to the example in question, the trouble shooter sent to corect the problem was an engineer—not a food technologist. The food technology was sound; only the engineering application could be at fault. Here is what he found. The vacuum pump was located almost a city block away from the vacuum closing machine, because the exhaust from a reciprocating vacuum pump is noisy and management wanted it to be located on an alley where few persons would be annoyed. The pipe line from the pump to the vacuum closing machine was 400 ft. long, had no less than 6 short radius elbows, and was only 1 inch in diameter! Pipe friction had reduced the flow of air under vacuum to the point where the volume of air evacuated was trivial. The remedy was to install a 4-inch pipe line, which had 16 times the cross sectional area of a 1-inch line.

The foregoing was a minor incident that anyone with good engineering training would have avoided, either by calculating the proper pipe diameter at the start, or by bringing the pump close to the point where vacuum was used, or both.

The next engineering problem of packaging concerns the design of a machine that was to close cans of a food under a 28-29-inch vacuum. Somehow, the cans never had a vacuum of more than 18-20 inches. The improvement came about when a man with engineering talent conjectured that the period of time when the cans were exposed to vacuum was too short to permit their adequate evacuation. He proved his point by slowing down the speed of movement of cans through the equipment. The cans then were evacuated to the full 28-29-inch vacuum. But the problem of doing it at normal line speed remained. In the end, the problem was solved by enlarging the ports so that the highly attenuated air had more time and more space through which to escape.

Making due allowence for the time-factor involved is an engineering function to which the laboratory type of food technologist should give more thought.

Here are more examples of Packaging troubles that arose from inadequate engineering. These are actual

case histories, but must be presented in a very condensed version.

Case A cost the owners about $5000 because of the engineering failure to allow for the time factor. It occurred in a plant where vegetables were being sterilized by heat in glass containers with metal tops. As any food technologist should be aware, the control of the pressure in such an operation is very critical in order to prevent blown lids or, conversely, buckled lids. A beautiful and very impressive panel of 15-lb. pressure, air-operated, automatic control instruments had been installed in a new plant but it failed to function properly and there were huge losses. An engineering investigation disclosed the cause: the ¼-inch tubing between retorts, control valves and instruments varied from 12 to 32 feet in length. The only practical way to solve the problem was to sacrifice the control instrument panel and mount each instrument directly over the retort that it controlled. After the change, the same instruments functioned properly.

Case B cost the owners something less than $1000 before it was corrected but it could easily have cost a great deal more. It, too, involved a glass packaging operation where the packaged product was subjected to pasteurizing temperatures in a continuous pasteurizer. The management decided on a higher speed of operation in order to get more production per hour. This required a higher pasteurizing temperature in the equipment. Accordingly, the temperature controls were set for 15° F. higher than before, but as soon as the operation started, a great deal of thermal shock breakage of containers occurred in the cooling cycle. Competent engineering advice was promptly sought. The engineer ordered the cooling water temperature raised by the same amount (15° F.) as the increase in pasteurizing temperature. After this, the thermal shock breakage ceased.

CONCLUSION

Only a very few examples of some of the engineering problems of food packaging have been cited. The subject is huge; more has been omitted than has been told.

The principal purpose of this presentation is to make you aware of the existence of a host of unsolved engineering problems of food packaging. Among other unmentioned engineering problems that deserve our attention are: insect proof sealing of cartons, net weight control, elimination of down-time on packaging lines, wage incentive plans, proper package specification writing, cost accounting of packaging operations, relation of package size and shapes to material-handling costs, relation of line speed and change-over time to economy of packaging operations, specifications, yield control, inventory control by higher speed operation, etc.—to mention only a few. The subject is huge.

The Team — The Food Engineer and the Food Technologist[a]

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(Manuscript received July 1, 1954)

Mr. Maier has set up a carefully conceived program which cannot help but drive home the true significance of food engineering. And much more than that. He has arranged an important session which will dissect food engineering, and lay bare its many functions and achievements, so that we all may come to understand and appreciate it better—and to profit thereby.

And here I am reminded of a slogan which I saw recently in the office of a harassed and overworked purchasing agent. It read "Don't confuse me with the facts. My mind is made up!"

Now if there is anyone whose mind is made up to the effect that food engineering is not vitally important to the future progress of our food industry, he most certainly will be an awfully confused individual as its significance is revealed.

To adapt a well-known commercial slogan to food engineering, "Progress is the most important product."

It seems to me that to devote a full-day session to discussing food engineering in itself constitutes progress. For this is the first time that the Institute of Food Technologists has devoted so much attention to this subject at an annual meeting.

This comes about, perhaps, because of a growing recognition—among men who direct the technical operations of food manufacturing—of a new era in the development of our Nation's greatest industry, the food processing industry.

It is the era of rapid—and often revolutionary—change and advancement in food factory operations. It is the period in which the last vestiges of kitchen mechanics are going into the discard. It is the time when the cake maker, the candy maker, the sausage maker—and all the other makers—become manufacturers in the true industrial sense of the word.

It really is a tremendously interesting, inspiring, and challenging time in the industry's development. But let us make no mistake. It is a time of the survival of the fittest. We are in a highly competitive, low-profit-margin industry. And when the pace-setters make cost-cutting, quality improving advances, those who stand still are in trouble.

When the homemaker goes marketing on Saturday, she thinks nothing of leaving a $20 bill at the supermarket. But while she's in that supermarket, she pinches the pennies on every purchase. The items with a penny engineered from the cost and price tab fill the wire baskets faster than competing items of equal quality.

But the homemaker is just as conscious of quality as

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[b] Editor, *Food Engineering*.

she is of cost. And she soon discovers which of two equally priced items has the better quality engineered into it.

The food engineer can affect sales in two ways. He can lower the price for the same quality. Or he can raise the quality for the same price. He does this by cutting the cost of food plant operations which add no value to the product. And this permits expense to be added where it increases value.

Let us quickly size up the role of science and technology and thus bring the different technical functions in food manufacturing into better perspective.

When food preservation and manufacturing stepped from the kitchen into the factory, food chemistry and bacteriology became of vital importance to success. Take canning for example. Causes of spoilage and the thermal death time curves necessary to make canned food products keep were essentially problems in applied science. And the progress made in our industry for decades was primarily based upon new scientific "know-how."

Applied science, or technology, is no less important today. Without it, few unit operations in food manufacture and preservation could be successfully carried out. Without it, we could look forward to little further progress.

So we have two essential technical forces in food factory operations—science and engineering. Each of these is required for successful performance nearly every step of the way—from raw materials to the finished product on the grocer's shelf. And here we have the vital food engineer-food technologist team.

You may wonder when I am going to specifically define the terms "food engineer" and "food technologist." If so, let me put your mind at rest. I don't intend to define them precisely. And here's why. In food plants you sometimes find a scientist functioning—to some degree, at least—as a technologist, a technologist as an engineer, and an engineer as a technologist.

THE FUNCTIONS DISTINGUISHED IN TERMS OF OPERATION

The future will see a more clear-cut distinction. But, for the present, let us look at the food engineer-food technologist team as a combination of engineering and scientific knowledge and skill. This may be achieved through the combined efforts of a food technologist and a chemical, mechanical, civil, or electrical engineer. Or it may be the teaming up in one man's head the necessary knowledge of food science and engineering. Basically, however, the technologist knows what should be done to food materials, and *why;* the engineer knows *how* to do it.

Here's what it takes to function as a full-fledged food engineer: (1) Have a fundamental knowledge of food chemistry and microbiology. (2) Know thermodynamics and the principles of mechanics. (3) Be well grounded in physics and mathematics. (4) Know materials of which structures, machines, and packages are made. (5) Have a thorough knowledge of the technical functions and operations involved in food manufacturing. I refer to such functions as sanitation and quality control; and to such operations as heat transfer, mixing, instrumentation, and materials handling.

Engineering also is a state of mind, or a particular approach to problems. The engineer looks first at the mechanics and the economics of an operation. He, by nature, favors the simplest, quickest, cheapest, and most direct method compatible with the quality of result desired.

The successful food engineer has the creative ingenuity of a Rube Goldberg. But he is the exact opposite in the execution of ideas. He is strictly a Scotchman in his use of machines, materials, labor, power, and time. And he looks at every existing operation, machine, and structure with a critical eye.

Let me cite a specific example. A friend of mine, and of many of you, took on the task of improving operations in a meat plant. He had never worked in this branch of the industry before, so he was not handicapped by knowledge of traditional methods. On his first venture into the plant he looked over the edible oil refining process. He saw the great array of old batch cookers and kettles, the laborious manual handling of materials, and the tremendous floor space involved. He also saw the smoke, smelled the stench, and grieved for the beating the fine fats were taking in processing.

His reaction was a quick and positive statement: "There must be a better way." He harnessed the food engineer-food technologist team and devised a better process. He sized up the job to be done on the raw material as one of separation. And he utilized well known food processing units and operations to set up a completely new refining system. The raw fat is chopped, passed through a tubular heat exchanger, comminuted to release the now liquid fat, and centrifuged to separate this fat from the solids. His process is simple, efficient, continuous, and sanitary. It requires little labor. It can be put into a corner of the plant. And it greatly improves product quality. I understand that this process now is in the hands of a well-known food engineering and equipment firm and will become available to the industry.

Or take the challenge of short-time high-temperature canning of fluid foods. You all are familiar with the use of a continuous, automatically controlled heat exchanger to bring the product to near 300 deg. F. in a matter of seconds, hold it a few seconds at that temperature, cool it quickly and discharge the sterilized product into sterile cans such as are used in the Martin aseptic system.

Here again you have the engineer's answer to a problem—a problem posed by food technologists. It's an adaptation of advanced concepts of heat exchange and instrumentation, with innovations and refinements to suit the system to the application.

But this could not have been worked out by a mechanical engineer, or even a chemical engineer, without the help of the food technologist. Why?—because the system is designed to kill microorganisms. The technologist knows what organisms have to be killed, and what it takes to kill them. He understands how critical are the times and temperatures, how vital it is to avoid recontamination, and what happens to product quality if temperatures are too high for too long.

A revolutionary new short-high process for non-fluid foods, like chop suey, was described to this group at Boston last summer. It involves, you will recall, the ingenious use of a stainless belt to carry the product through a high-temperature sterilizing chamber in continuous flow. It utilizes special valves to transfer the product from the pressure sterilizing chamber into a pressure filling chamber without physical damage to the product. It incorporates the idea of filling at sterilizing temperature in a pressure chamber.

Here, again, is the engineer's practical answer to a technologist's dream.

Here, too, technology has worked hand in hand with engineering all the way from design through "shake-down" operation. And consider the highly successful, and only a few short years ago revolutionary, process for concentrating citrus juice at low temperature, under high vacuum, in continuous flow, at tremendous volume. Technology created the opportunity, and showed the way. But it took some mighty fine engineering to design and build the equipment.

Incidentally, I am told that the first citrus juice concentrating plant was created by engineers who never had been inside a food factory. Of course, they were working with information supplied by technologists. In any event, it certainly took technologists to make the process work satisfactorily—and still does.

When it comes to designing and building better food plant equipment, or any other kind of machinery, engineering is deeply involved. No one will deny that it takes a knowledge of materials, mathematics, physics, mechanical principles, and even electricity to design modern machinery.

But sad to relate, not everyone realizes that it takes a knowledge of food technology too. And this is true of even the simplest food machine. The metals which come in contact with

the food must be selected to avoid metal pick-up which affects product quality. The metal too, must resist corrosion by the food product. The mechanism of the machine must be such that it does not physically damage the product or food material handled. And then you have the terrifically important factor of sanitary design.

Just as it takes the food engineer-food technologist team to design squipment, it also takes the same team to select and purchase new equipment best suited to do the job involved. To the technologist, an electric motor may be a simple device. It's just something that makes the wheels go round. It is not part of the process. And it never comes in contact with the food, except when some is spilled on it.

But to an engineer a motor is far from simple. Its "innards" are the complex product of Steinmetz-like genius. It involves amperes, volts, ohms, sine waves, power factor, magnetic flux, capacitance, and inductance. It is carefully designed to run at full load at a certain temperature. The windings are insulated to withstand certain moisture conditions. The shell may or may not keep out water, moisture or dust, or be explosion proof.

So what kind of a motor do you want? Well, a technologist would hardly be expected to know. But it should be duck-soup for an engineer to select a motor for a given job.

I know of a very large food company which uses motors by the thousand. And the purchasing agent selects them pretty much on the basis of price. When they break down due to improper selection, the maintenance man either fixes them or the purchasing agent buys some more. Gentlemen, every food plant needs an engineer to help buy equipment.

But suppose a plant does have an engineer, and management asks him to select a new bulk handling system for flour. Fine. He considers the physical requirements and picks a system that will do the job. The equipment is duly ordered and in time installed. Then one fine day the director of quality control finds a high-protein product on his hands—one with insect fragments in it. Tracing the trouble, he finds that the handling system never quite empties itself of flour, and further that there are no drop-bottoms on the conveyors to permit cleaning.

At that point the engineer is in trouble. He is literally up to his ankles in infested flour.

If the food engineer-food technologist team had selected the new bulk handling system, this unhappy situation would have been avoided—with its resultant loss of product and customers, wasteful expenditure of money, and production delays.

UNIT OPERATIONS REQUIRE TEAM WORK

Here I should like to run through a list of basic unit operations and functions involved in food manufacture and processing. And as I call them off, ask yourself this question: "Does it take a food engineer-food technologist team to handle them effectively and to make continual improvements?"

Here they are:

Quality Control	Heat Transfer	Washing and Peeling
Sanitation	Refrigeration	Size Reduction
Materials Handling	Air Conditioning	Proportioning
Automatic Control	Waste Disposal	Mixing
Automation	Moisture Removal	Forming
Packaging	Separation	Coating

As I see it, everyone of these calls for the technical team. And I believe you will agree that at least most of them do.

Let us look at food manufacturing an an elemental sort of way and ask ourselves where the team comes in.

Food manufacturers take materials apart, clean and grade them, put materials and ingredients together, form the products into the desired sizes and shapes, treat them with heat or cold, let them undergo chemical or biological change under controlled conditions, and put the finished products into technically proper packages.

All the while, the manufacturer is moving materials and ingredients from point to point in plant and process, maintaining a sanitary environment, determining and checking quality characteristics, and controlling temperature, time, pH, and other variable factors.

Seems rather obvious that we have to call out our technical team for practically every one of these plays.

So far we have considered operations in the industry pretty much as they are today. Now let's take a look at what's ahead. Let us see where our technical team fits into the all-important future scheme of things.

In quality control we see new in-process analytical instruments coming more and more into the picture. Continuous processes can't wait for tests at a remote lab bench. We need instruments to dynamically measure, and sometimes control, qualities such as color, density, texture—even odor and taste. An example is the potential use of an X-ray instrument for continuous flow density analysis and control.

In sanitation, easier, faster, mechanized cleaning is becoming a "must." And better design of plants, machines, and pipelines in respect to sanitation are continually being work out.

In materials handling, a marked trend to bulk and unit-load handling is apparent. And handling operations must be automated to save labor and cut costs.

Automatic control is a new force in processing. Already we have seen a tremendous increase in applications—yet we are only started. Most of the new processes developed in the future will be "hung" on instruments. That is to say, they will be completely dependent upon instruments for successful operation.

Automation in the food plant of the future will make most operations tick along without direct aid from human hands. Electric switches, photocells, and relays are cheaper and more reliable than people. We have a particularly good example of what is ahead—in both automatic control and automation. It is the automatic sequence control system applied on a pilot plant basis to aseptic canning.

Process conditions are kept precisely on the beam automatically. And instruments switch the system from sterilizing to canning, to product recirculation, and to standby. They shut down the process automatically. Even the operations of can conveyors and filling and closing machines are synchronized with product flow by automatic sequence controls. Here is one pattern for future control and automation of complex operations. Here is a way to assure product quality, eliminate human errors, increase output, and save labor.

Packaging line speeds will be stepped up considerably. And the newer materials, together with machines to handle them efficiently, will permit far reaching changes in food packaging. For example, we have a new transparent film that has one-third the tensile strength of steel and will stand a temperature of 302° F. for heat sterilization. It hasn't been used yet for packaging food. Some day it will be.

Heat transfer is perhaps the most basic of all food process operations. And here, recent advances point to significant future improvements. Continuous short-high processing, precisely controlled, is providing the impetus. New heat-transfer mediums, such as water under high pressure, may well come into use. A lot of progress in thermodynamics is likely to come out of current developments in high-pressure-water reactors for atomic power plants.

Another very basic operation, refrigeration, is playing a steadily increasing role in food processing, transportation, and storage. Equipment is being improved, and new techniques and applications developed. The heat pump already is at work in the concentration of citrus juice. And vacuum cooling is finding significant new uses for both in-process and product cooling.

Air conditioning is becoming more and more of a "must" for efficient food processing operations. It will find many new applications, for at least four excellent reasons:

1. Retention of quality and workability of raw materials and packaging materials.
2. Maintenance of optimum conditions for performing a process.
3. Prevention of spoilage in finished goods.
4. Protection against contamination of material or product by airborne microorganisms.

Waste disposal is a headache now. It will become a bigger one in the years ahead because of tighter restrictions on the nuisance aspects of waste. Furthermore waste offers three challenges: One is to reduce the quantity. A second is better disposal methods. And the third is development of useful and profitable byproducts.

Advances in moisture removal have set a challenging pace for tomorrow. High-vacuum evaporation is leading the parade.

Moisture removal offers tremendous economic advantages through reduction of the overall costs of labor, packaging, and transportation. We need look no further than soluble coffee for an example. And juices present equal opportunities. Already we have a 35 to 1 superconcentrate in the pilot plant and high quality powdered juice in commercial production.

Much progress is going to be made in separation, with centrifuging leading the way. A continous sugar centrifuge has been developed. And a new machine which takes solids out of liquids, then automatically opens its innards to disgorge them, is getting much attention.

Washing and peeling operations present many problems that must be solved. And some think that ultrasonic washing will be applied to food materials before many more years go by.

Size reduction equipment is rapidly being improved, and is finding new applications. Comminuting and disintegrating challenge the imagination. They make new products possible and improve the quality of old ones. They open the way to new processes, and simplify existing ones.

Automatic proportioning of ingredients is cutting costs and improving product quality. Practically any type of material, wet or dry, can be proportioned continuously in any quantity. You will see a lot more of this done in the future.

Effective and efficient mixing is a key to quality for many manufactured foods. Continuous mixing, combined with continuous proportioning of ingredients, is simplifying processes, increasing capacity, improving quality, saving labor and floor space.

As most of you know, a continuous bread dough mixing process threatens to make obsolete even the most modern of bread bakeries in the immediate future.

Very little is known about the science of mixing. Here is a challenge to the food engineer-food technologist team.

Forming manufactured products into the right shape and size has been mechanized, and the trend is to continuous operation. Extrusion and sheeting—followed by cutting and stamping—are playing an important role in this progress. A new candy bar method nicely demonstrates what can be done. The candy is formed into a thick sheet by refrigerated rolls. The sheet drops onto a traveling stainless steel belt. It is hardened as it passes through refrigerated tunnels. Another sheet of candy is formed and laid on top of the first in continuous motion. Then the laminated sheet is continuously cut into strips, and cross cut into bars.

Putting the finishing touches on a product by coating also is being performed by continuous mechanized operations. Ice cream bars, for instance, are coated at a rate of 165 a minute by a bottomer and enrober. And marshmallow topping is deposited on cookies at high speed by traveling extrusion nozzles. Electrostatic coating—an adaptation of electrostatic painting—presents a real challenge. It may even be used to smoke meat quickly in continuous flow—a case of coating the meat with smoke particles.

A LOOK AHEAD

Finally, as we look to the future, we are deeply interested in cold sterilization by ionizing radiation from electronic devices or radioactive atomic waste.

And cooking and sterilization by dielectric heat continues to be studied by the industry. There is a chance that canned hams will be sterilized by this method so that they need not be held under refrigeration.

Then we have the tool of ultrasonics, which I mentioned as a possible revolutionary cleaning method. In Germany it has been used to increase the extraction of hops in the brew kettle. There are other potential applications in our industry when the problem of greater power output has been solved.

Every one of these things for the future—many, many more than I have mentioned—and still others not yet dreamed of—will challenge the food engineer "know-how" and the food technologist "know-why." It will take their team-work to adapt and adopt them, to operate and control them. Real honest-to-goodness engineering will be needed. The engineering approach is as essential as it is indispensable.

Now all these demands for technical teamwork lead us to a serious and challenging situation. Our industry is critically short of the kind of technical teamwork that will permit it to modernize and expand as dictated by economic pressures and business opportunities.

There are 10,000 food factories (of a total of 36,000) with 20 to 99 employees. Each of these needs this team of technical "know-how" and "know-why." Another 3,000 food factories have 100 or more employees. On the average, each of these can use two of the teams. Then at least 1,000 companies producing equipment and "technical" materials and supplies for the industry each needs at least one food engineer-food technologist team.

This adds up to 17,000. There now are about 7,000 engineers in the industry. So 10,000 more are needed.

By way of comparison, the chemical processing industry has at least 35,000 chemical engineers and 10,225 plants with more than 20 employees.

A survey of men directing the operations in food plants reveals that 70% find food engineering involved in their work. Among research directors, food technologists, and chemists, the figure is 74%. Considering the number of corporate officials, managers or superintendents, scientists, engineers, and others in key positions in the industry, this adds up to a lot of engineering.

The food industry is spending 800 million to a billion dollars annually for new plants and equipment. Some big companies put $5,000,000 and more a year into modernization. And the pace-setters report intentions to increase the capital investment per worker significantly in the next 5 to 10 years.

On top of this, the industry came into 1954 with the greatest demand ever for its products, particularly the newer convenience items. It will take modernization and the food engineering-technology team to capitalize upon this opportunity. And only through engineering can the results of research and product development be put into commercial production at a profit.

All the while competition gets tougher in the food industry as the pace-setters modernize for higher efficiency. To stay in the swim, all food companies must have their food engineer-food technologist teams pulling them ahead.

Although up slightly in the last half of 1953, the average food manufacturer's profit was then only 2.4 cents on the sales dollar. That is by no means enough. And the only way to raise it is to engineer more efficiency into operations, put profitable new products on the market, and improve existing products in relation to competing items. Again, it is the engineer-technologist team that can do it; and only this team, led by enlightened management, will take the industry forward to full achievement of its opportunity.

It is high time for all food companies to take their heads out of the sands of times gone by and face up to the demands and the challenge of the present and the future.

From here on in, the only food manufacturers that will survive are those which hitch their wagons to food engineer-food technologist teams.

Combined Method for the Heat and Cold Stabilization of Wine[a]

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(Manuscript received June 28, 1954)

Laboratory procedures for a combined use of bentonite and gelatin for clarifying wine are described. The method results in wines of cleaner taste and without impairment of varietal characteristics.

Bentonite, a montmorillonite clay, is widely used in California wineries as a clarifying agent. Methods of using bentonite vary somewhat, although it is generally agreed that the preparation of a bentonite slurry is more effective than adding the material directly to the wine. Slurries may be prepared either in wine or water, and may be added immediately after preparation or aged for several days before using. The slurry is generally introduced, at a carefully controlled rate, through a Y connection on the suction side of a circulating pump connected to the bottom and top of the tank being treated.

The bentonite treated wine usually clarifies slowly unless it is hot. Therefore, the slurry is either added to dessert wines immediately after fortification, when the temperature has been increased by the addition of high proof brandy, or the temperature of dessert or table wine is raised by means of a heat exchanger to 100°-140° F.

It is rather common practice to flash heat wines to 185°-210° F. to assist the removal of unstable proteins and thus aid the attainment of heat stability. The wine is subsequently bentonited, filtered, chilled (14°-25° F. for varying periods of time depending upon the wine and the wine maker) and filtered again. This finishing process enables the wine (in varying degree) to remain stable if subsequently exposed to unusual temperature variations.

A series of tastings of wines raised to high temperatures showed that frequently the quality of the wine was adversely affected. This was particularly true of the better varietal wines. Because of this it was considered advisable to attempt the development of a stabilization procedure which would permit the elimination of the heat treatment.

Philips *(3)* found that dessert wines treated with bentonite alone became as heat stable as wines raised to elevated temperatures although settling time was prolonged materially. Gortner *(1)* states that coacervation is a mutual precipitation of oppositely charged colloids. In order for a coacervate to form it is not necessary for the electrostatic forces of the two components to be exactly balanced. He points out that bentonite has a negative charge, whereas gelatin, below a pH of 4.7, has a positive charge.

Because of the above mentioned phenomena it was believed that the use of bentonite without heating would produce the desired stability, and that the addition of gelatin to the bentonite fining would be of value in shortening the settling time. A number of wine chemists were consulted and it was found that, although several were using a combined bentonite-gelatin process, there was no general agreement as to order of addition or amounts required.

EXPERIMENTAL PROCEDURE

A number of laboratory tests were made on various type wines to determine the preferred order of addition with bentonite and gelatin. It was found that the best results were obtained when bentonite preceded gelatin. When the gelatin was used prior to the bentonite, either a heat or cold instability was obtained upon subjecting the clarified wine to temperatures of 140° F. for 16 hours and 25° F. for one week.

The next step was to vary the amounts of bentonite and gelatin to determine the optimum quantities. It was found that 3 pounds of bentonite and 4 ounces of gelatin per 1000 gallons appeared to give the best heat stability. Following addition of the clarifying agents the wine was held for 3 weeks, filtered, and then chilled for 3 weeks to obtain cold stability.

It became increasingly evident that there was an interaction between the fining and chilling processes. Wines that were fined and then filtered before chilling tended to become more cold stable, and wines that were chilled and then filtered before fining tended to become more heat stable. Because of these effects it was felt advisable to set up a series of experiments in which the wine was bentonite-gelatin fined and subsequently chilled before filtration. It was thought that this procedure would result in the removal of material which was unfinable at cellar temperature, and provide a large number of foci for the deposition of tartrates and other materials.

One port and several table wines were used in this experiment. A one-fifth gallon bottle of each was bentonite-gelatin fined at 85°, 65°, 45°, and 25° F. The bottles were then held at 25° F. for 3 weeks, filtered and checked for heat and cold stability. All samples except those fined at 25° F. filtered at the same rate. The 25° F. fined samples were filtered only with great difficulty. As the stability attained at all four fining temperatures was good, it was decided that plant finings should be conducted at the lowest temperature which permitted normal filtration rates—namely 45° F.

As a result of the laboratory experiments the following procedure was adopted for plant clarifications:

a. Sufficient slurry to provide 3 pounds of bentonite per 1000 gallons is prepared by adding 0.5 pound of bentonite to a gallon of wine and violently agitating for a least an hour. The freshly prepared slurry is introduced slowly through a "Y" on the suction side of a centrifugal pump which is circulating the wine at 45° F. or over in the tank. Circulation of the wine is continued until all the wine has theoretically passed through the pump.

b. A 6% solution of edible grade gelatin is prepared by dissolving sufficient gelatin in warm water to provide 4 ounces per 1000 gallons of wine. The gelatin solution is then added to the wine in the same manner as the bentonite slurry.

c. The wine in the tank is cooled by means of a stainless steel coil to 16°-18° F. for dessert wines or 23°-25° F. for table wines and held at the desired temperature for 3 weeks. During this period the wine is slowly agitated by a stirring motor having a propeller on the end of a 3-foot shaft. Circulation is discontinued at the end of the nineteenth day to allow settling of the suspended material prior to filtration.

d. At the end of the holding period the wine is rough filtered through a plate and frame filter using only canvas cloths and Dicalite 4200 or Johns Manville 545 diatomaceous

[a] Presented at the Fourteenth Annual Meeting of IFT, Los Angeles, California, June 28, 1954.

earth. When the flow rate becomes too slow, the filter is backwashed with the filtered wine, more diatomaceous earth is added, and filtration is continued.

e. Immediately following the rough filtration the wine is polish filtered through the same filter using E and D 301.052 papers on the canvas cloths and a precoat of Johns Manville Filter Cel or Dicalite Super Aid as recommended by Holden *(2)*. Johns Manville 545 or Dicalite 4200 is used in the filter hopper during this filtration.

RESULTS AND DISCUSSION

The process described above resulted in better heat and cold stability. Although heat stabilities varied slightly, the processed wine could usually withstand a holding period of 6 days at 140° F. followed by holding at room temperature overnight without showing an appreciable increase in the Nepholos reading. Wines held at 25° F. remained relatively clear for as long as 3 months. An occasional wine developed a slight haze or precipitate after one month. However, the haze or precipitate invariably disappeared when the wine was warmed to room temperature.

Brown oxidized pigment was removed from white wines by this process. Red wines retained more color than when fining and chilling were used separately. All the wines seemed to be much cleaner to the taste, with the desirable varietal character apparently unaffected by the processing. Processing losses were decreased, and processing time reduced to approximately one month.

Though improvements have been made in the finishing process, further experimentation will undoubtedly result in additional improvements. Electrophoretic studies may show a more effective ratio of bentonite-gelatin or an optimum temperature-time relationship. It is also believed that determination of the effect of various clarification processes on the protein level of the wine may lead to more effective and economical stabilization procedures.

SUMMARY

A combined bentonite-gelatin clarification gave better results than bentonite alone. Optimum quantities were found to be 3 pounds of bentonite and 4 ounces of gelatin per 1000 gallons of wine. Refrigeration of the treated wines followed by filtration was found to be more effective than the usual practice of filtration of the clarified wines prior to refrigeration. Use of this new finishing procedure resulted in cleaner tasting wines without impairing the varietal characteristics.

LITERATURE CITED

1. Gortner, R. A. *Outlines of Biochemistry*. 2nd Ed., 1944, John Wiley & Sons, Inc., New York.
2. Holden, C. *Proceedings of the American Society of Enologists*. 1953, American Society of Enologists, Davis, California.
3. Philips, E. O. (Private Communication, 1948.)

Processing Characteristics of Colored Texas Grapefruit. I. Color and Maturity Studies of Ruby Red Grapefruit[a]

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(Manuscript received July 1, 1954)

In order to process juice from colored grapefruit successfully, more information was necessary about the development of color, and its relationship to maturity. For opening studies on this problem the Ruby Red was selected because it is probably the most widely planted of the colored varieties in Texas. Measurements of color and some chemical and physical characteristics were made at intervals of two weeks for a period of approximately eight and one-half months. These measurements included visual and reflected color; average weight; Brix, acid, naringin, lycopene, and carotene content. Color was found to be strongest early in the season, before fruit reached its peak of processing quality, and had begun to fade when this peak had been reached. These studies indicate that the combination of good color with high flavor characteristics is limited to a relatively short period.

In January, 1951, studies were initiated at this laboratory with the object of developing practical methods for the commercial processing of juice from Texas red and pink grapefruit. During the progress of this research it became apparent that the development and fading of color with relation to maturity in these varieties would be an important factor influencing processing techniques, and in July, 1952, exploration of this phase of grapefruit color was started.

Very little is revealed in the literature about the behavior of pigments in colored grapefruit. Matlack *(7, 8)* isolated and identified the pigments of Foster and Marsh pink grapefruit; Khan and Mackinney *(6)*, and Huffman, Lime, and Scott *(4)* have identified those of the Ruby Red. In all three varieties the principal pigments were found to be lycopene and beta carotene.

Though both pink and red grapefruit have been grown in the Lower Rio Grande Valley of Texas and in Florida for a number of years, no completely satisfactory method of utilizing these varieties for canning has been evolved. Juice from colored grapefruit, canned alone, has several disadvantages. Though it has a slight pinkish tint, the color is too weak to present the attractive appearance of the fresh fruit, at the same time deviating considerably from the oyster-white the consuming public has learned to expect in canned grapefruit juice of high quality. Furthermore, after a few months' storage, the faint pink tint changes to an undesirable brownish cast.

[a] Presented at the Fourteenth Annual Meeting of the Institute of Food Technologists, July 1, 1954, Los Angeles, California.

[b] One of the laboratories of the Southern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture.

So long as the volume of white grapefruit produced was much greater than that of colored, processors avoided the problem by mixing small quantities of colored juice with much larger proportions of white. In recent years, however, popularity of colored grapefruit on the fresh market has resulted in a preponderance of these varieties over white grapefruit in new plantings. This is particularly true in the Lower Rio Grande Valley of Texas, where most of the groves were destroyed by the freezes of 1949 and 1951. Pink and red varieties are estimated to comprise 80% of the replantings.

In the search for suitable processing methods, the primary aim was to produce a canned single-strength juice which would have and retain as much as possible of the distinctive color of the fresh fruit. Observations during processing tests indicated that color was most intense early in the season before the fruit reached full maturity, as determined by Brix-acid ratio, and fading began before the start of the usual processing season. Preliminary studies indicated that knowledge of color in relation to Brix, acid, naringin, and other quality factors is essential to production of a canned juice with optimum qualities of both color and flavor. These relationships, as revealed by studies at this laboratory, are presented in this paper.

EXPERIMENTAL PROCEDURE

Source of material. As a source of fruit, 45 Ruby Red grapefruit trees were selected in an orchard near Alamo, Texas. These trees were about 14 years old, and had survived the freezes of 1949 and 1951 with minor damage. Fruit from these trees was harvested as required for laboratory use. Six trees were chosen at random, marked, and used as the source of all fruit needed for pigment and maturity studies.

Methods. Samples consisting of 5 fruit from each of the 6 trees were obtained at intervals of 2 weeks, beginning July 27, 1953, and ending April 5, 1954. Care was taken to obtain samples at random as to size and location. The 30 fruit comprising each sample were brought to the laboratory, washed, measured, and weighed to the nearest gram. The fruit was then cut in halves, visual appearance noted, color photographs of 4 representative fruit taken, and one half of each fruit used for reflectance measurements.

A Photovolt Reflectance Meter, Model 610,[c] was used to measure reflectance. Operation of this instrument on citrus juice has been described by Worthington, Cain, and Wiegand *(14)*. Color measurements were made by reading the reflectance values obtained with the amber, green, and blue filters specified for tristimulus measurements. Readings on the 30 fruit samples were made by making four reflectance measurements on one-half of each cut fruit. The 120 filter readings for each filter were averaged and the 3 averages used for computing the ICI notation (x, y, and Y) of the fruit sample. The ICI notations were derived from the following formulae:

$$X = .8A + .18B$$
$$Y = G$$
$$Z = 1.18B$$
$$x = \frac{X}{X + Y + Z}$$
$$y = \frac{Y}{X + Y + Z}$$

A = amber filter reading
G = green filter reading
B = blue filter reading

[c] The mention of equipment and products does not imply that they are endorsed or recommended by the U. S. Department of Agriculture over other equipment or products having the same or similar properties.

The methods used for determining the percent of lycopene and carotene in the flesh of the fruit were adapted from Strain's *(12)* chromatographic technique for separating these pigments, and the Zscheile and Porter *(15)* method for analysis. Chard, Francis, and Graham *(2)* describe a similar procedure for determining the lycopene and carotene content of tomato pulp. Absorption data were obtained with a Cenco Sheard Spectrophotelometer.[c] To prepare the sample, rag-free pulp from four sections of each half was removed with a knife and the segments blended in a Waring blender[c] for 3 minutes to insure a representative sample. Duplicate 100-g. samples were removed while the blender operated at moderate speed and 100 ml. of methyl alcohol added to each sample. Samples were allowed to stand for 30 minutes, then 2 g. of Hyflo Super-Cel[c] were added to each, and the samples filtered through a Super-Cel pad on a Buchner funnel. The filtrate containing the methyl alcohol water-soluble substances was discarded. The carotenoids were removed by blending the filter pad and paper in a micro-blender cup with 50 ml. of acetone for 1 minute, filtering and washing with 20 ml. of acetone. The pulp and pad were extracted and washed twice more in the same manner and the combined extracts placed in a 1000-ml. separatory funnel, 50 ml. of Skellysolve B[c] added, then 100 ml. of water, and the Skellysolve-pigment phase allowed to separate. The aqueous acetone was further extracted with Skellysolve until the extract was colorless. Lycopene and carotene were chromatographed on a 1-to-1 mixture by volume of magnesia and Hyflo Super-Cel. The amounts of carotene and lycopene contained in the eluates were estimated photometrically, using the Cenco Sheard Spectrophotelometer set at 465 mμ for carotene and 485 mμ for lycopene. Standard curves were prepared from carotene purified as described in A. O. A. C. *(1)* and from recrystallized lycopene prepared by the method of Strain *(12)*.

Naringin was determined on duplicate 100-g. samples of the blended sections by the colorimetric procedure outlined by Davis *(3)*. One hundred ml. of methyl alcohol was added to each sample, then 2 g. of Hyflo Super-Cel, the sample filtered through a Buchner funnel and the pad and pulp extracted with 50% methyl alcohol-water to remove naringin until the volume of the extract totalled 500 ml. One ml., equivalent to the 0.2 ml. sample described by Davis, was used for color development. Color was measured in a Lumetron Colorimeter,[c] using a 420 mμ filter. Recrystallized naringin was used to prepare a standard curve.

RESULTS AND DISCUSSION

The data tabulated in Tables 1 and 2 were obtained from fruit picked during the period from July, 1953 through April, 1954, in the course of which time the fruit varied from very immature to definitely overmature.

Variations in some of the physical and chemical characteristics of the fruit are shown in Table 1. During the period covered, the average weight increased approximately 2.5 fold, from 207 to 543 g. It is of interest that after February there was no marked increase in fruit size. Acidity, calculated as citric, decreased from 2.43 to 1.0%. The change in Brix-acid ratio, so important as an index of maturity, was occasioned by a decrease in acidity rather than an increase in the amount of sugars present. Juice obtained the last of October met the Government sugar-acid requirement for Grade A *(13)* but optimum flavor had not developed, and naringin content was high. Most canners prefer fruit that is more mature, with lower naringin and a Brix-acid ratio above 8.

The percentage of naringin, the bitter principle of grapefruit, decreased as the fruit matured, but reached a plateau at about the time (February) the fruit was full-grown. Apparently little or no naringin was formed during the later stages of fruit growth. These results

TABLE 1

Changes in composition of edible portion of Ruby Red grapefruit during growth and maturity

Date of sample	Average wt. Gs.	Acid %	Brix deg.	Brix-Acid ratio	Naringin %	Lycopene mg./100 g.	Carotene mg./100 g.
7-27-53	207	2.43	12.5	5.1:1	.....	0.93	0.07
8-11-53	215	2.09	12.2	5.8:1	.....	1.00	0.08
8-24-53	266	1.93	11.6	6.0:1	.075	1.15	0.10
9-8-53	298	1.68	10.4	6.2:1	.068	0.91	0.12
9-21-53	337	1.63	10.3	6.3:1	.058	0.91	0.14
10-5-53	320	1.49	10.3	6.9:1	.051	0.72	0.14
10-19-53	357	1.39	10.1	7.2:1	.047	0.38	0.23
11-2-53	407	1.37	10.1	7.4:1	.043	0.49	0.31
11-16-53	429	1.33	10.0	7.5:1	.041	0.17	0.31
11-30-53	461	1.32	9.8	7.4:1	.039	0.16	0.34
12-14-53	479	1.25	9.8	7.8:1	.034	0.21	0.31
12-28-53	484	1.31	9.6	7.3:1	.038	0.19	0.37
1-11-54	477	1.23	10.2	8.3:1	.038	0.19	0.34
1-25-54	515	1.29	10.2	7.9:1	.033	0.11	0.33
2-8-54	543	1.23	10.2	8.3:1	.033	0.03	0.33
2-23-54	535	1.27	10.4	8.2:1	.029	0.10	0.31
3-8-54	538	1.13	10.4	9.2:1	.027	0.10	0.34
3-22-54	534	1.02	10.2	10.0:1	.023	0.05	0.23
4-5-54	517	1.05	10.0	9.5:1	.028	0.08	0.22

confirm the findings of Maurer, Burdick and Waibel *(9)* but differ somewhat from those of Kesterson and Hendrickson *(5)*.

The percentage of lycopene increased rapidly during August, then began a sharp decline which lasted until the middle of November. The residual amount decreased slightly from November to May. Carotene gradually increased during the growth of the fruit, July through January, remained fairly constant until the middle of March, and then declined. From November 16 on, the percentage of carotene exceeded the percentage of lycopene in the samples.

Table 2 shows color variations. Visual color (redness) was judged *good* during July, August, and to the middle of September, and *excellent* during the latter part of September and through October. Color faded to a rating of *good* during November and part of December, and continued to fade to *fair* and *poor* as the season progressed.

Nickerson's index of fading (I) *(11)* was derived from the reflectance readings using a base color IYR 4.00/2.00 [Munsell notation *(10)*] by the following formula:

$$I = C/5\ (2dH) + 6dL + 3dC \text{ where}$$

C = Chroma
dC = difference in Chroma
dH = difference in Hue
dL = difference in Value

(I) agreed with visual ratings after the fruit reached maximum coloration (Figure 1). Values of 11.5 and below indicate excellent color. Values of 13 to 15 indicate good color, 15-17.5 fair, and above 17.5 poor color or faded appearance. Although lycopene and carotene are responsible for the color of the grapefruit, amounts of either, or the total of the two, do not correlate exactly with color measured either visually or photometrically. Certain other variables, such as width of the segments, size of the fruit, turbidity of the juice sacs, may have influenced the color to an unknown extent.

Data indicate that if canners desire maximum color consistent with good quality it will be necessary to process during a rather short period when naringin values are low, Brix-acid ratio is approximately 8, and while there is sufficient pigment in the pulp to give an attractive appearance. Continued work on factors influencing color and maturity and their relationship to processing quality is necessary to establish standards of measurement and processing techniques which will integrate these variables to produce the highest possible quality of colored canned grapefruit juice.

TABLE 2

Color variations of the edible portion of Ruby Red grapefruit during growth and maturity

Date of sample	REFLECTANCE ICI Notations			Index of fading	Visual rating
	x	y	Y		
7-27-53	.395	.350	26.9	19.86	Good
8-11-53	.398	.349	22.7	16.49	Good
8-24-53	.398	.345	21.0	15.19	Good
9-8-53	.401	.348	19.4	13.65	Good
9-21-53	.393	.347	17.5	11.41	Excellent
10-5-53	.393	.349	16.8	11.38	Excellent
10-19-53	.395	.350	16.2	11.33	Excellent
11-2-53	.394	.358	15.0	12.17	Good
11-16-53	.398	.362	15.1	11.78	Good
11-30-53	.386	.359	16.1	13.09	Good
12-14-53	.388	.359	16.2	13.51	Fair
12-28-53	.382	.362	16.4	14.59	Fair
1-11-54	.390	.365	16.4	15.77	Fair
1-25-54	.392	.363	16.3	15.38	Fair
2-8-54	.386	.366	16.2	15.92	Fair
2-23-54	.393	.366	17.3	17.51	Poor
3-8-54	.384	.369	17.3	17.91	Poor
3-22-54	.379	.375	17.7	20.04	Poor
4-5-54	.377	.375	17.9	20.55	Poor

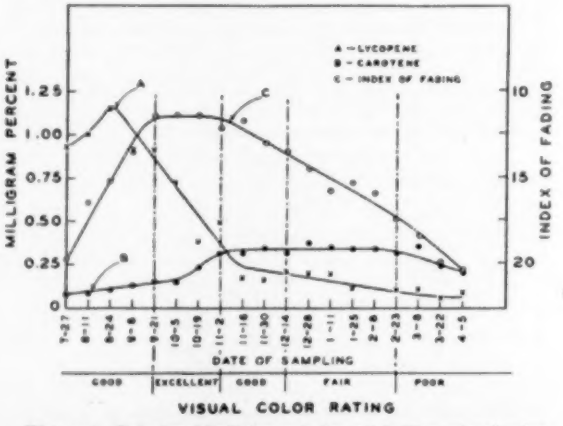

Figure 1. Relationship between index of fading, visual color, and lycopene and carotene content of Ruby Red grapefruit during growth and maturity.

SUMMARY

Color was highest in Ruby Red grapefruit before the fruit reached full size, while it was still high in naringin, and immature according to the Brix-acid ratio. Color faded as the fruit reached optimum maturity. Lycopene decreased and carotene increased in the fruit until late in the season, when both pigments declined. Good pulp coloration, together with low naringin and low acidity occurred during a relatively short period as the fruit approached maximum weight.

LITERATURE CITED

1. Assoc. Off. Agr. Chems. Official and tentative methods of analysis. 1945, 6th ed., p. 600.
2. Chard, J. R., Francis, F. J., and Graham, T. O. The effect of chemical defoliation on the quality of canned tomatoes. *Food Technol.*, **8**, 95-96 (1954).
3. Davis, W. B. Determination of flavonoids in citrus fruits. *Ind. Eng. Chem., Anal. Ed.*, **19**, 476-8 (1947).
4. Huffman, W. A. H., Lime, B. J., and Scott, W. C. Processed juices from Texas red and pink grapefruit—a progress report. *Proc. Rio Grande Valley Hort. Inst.*, **7**, 102-5 (1953).
5. Kesterson, J. W., and Hendrickson, R. Naringin, a bitter principle of grapefruit. Univ. of Fla. Agr. Exp. St. *Bull. 511* (1953).
6. Khan, M., and Mackinney, G. Carotenoids in grapefruit, *Citrus* Paradisi. *J. Plant Physiol.*, **28**, 550-2 (1953).
7. Matlack, M. B. Pigment of the India Red pummelo (Citrus Grandis Osbeck) *J. Wash. Acad. Sci.*, **24**, 385-6 (1934).
8. Matlack, M. B. Pigments of pink grapefruit, Citrus grandis (L. Osbeck) *J. Biol. Chem.*, **110**, 249-53 (1935).
9. Maurer, R. H., Burdick, E. M., and Waibel, C. W. Distribution of naringin in Texas grapefruit. *Proc. Rio Grande Valley Hort. Inst.*, **4**, 47 (1950).
10. Munsell, A. H. *A Color Notation.* 8th ed. 72 pp. 1936. Munsell Color Co., Baltimore, Md.
11. Nickerson, D. Color measurement, and its appplication to the grading of agricultural products. U. S. Dept. of Agr. *Misc. Pub. 580* (1946).
12. Strain, H. H. *Chromatographic Adsorption Analysis.* Vol. 2, 1942. Interscience Publ. Co., New York, N. Y.
13. United States Standards for Grades of canned grapefruit juice. U. S. Department of Agr. Production and Marketing Adm., 1949. Washington, D. C.
14. Worthington, O. J., Cain, R. F., and Wiegand, E. H. Determination of color of unclarified juices by reflectometer. *Food Technol.*, **3**, 274-7 (1949).
15. Zscheile, F. P., and Porter, J. W. Analytical methods for carotenes of lycopersicon species and strains. *Ind. Eng. Chem., Anal. Ed.*, **19**, 47-51 (1947).

Factors Affecting the Quality of Pre-Peeled Potatoes[a,b]

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A "convenience" product, pre-peeled potatoes, has come into widespread commercial acceptance in the past few years. Peeled, raw, white potatoes are prepared in various styles—such as whole, cut, and french fried—and then treated by dipping in an antidarkening solution, packaged, and stored at temperatures of 32 to 40° F. Their popularity is indicated by the recent issuance (June 8, 1954) of the first U. S. D. A. "Standards for Grades of Peeled Potatoes." A recent estimate *(1)* shows that about 2,500,000 bushels of potatoes are now being pre-peeled annually. Currently the major outlet for the product is to restaurants, hotels, schools, and other institutional channels, but a retail market appears to be also shaping up.

Some specific advantages accruing to the user of pre-peeled potatoes include: (a) elimination of peeling operations and attendant waste disposal problems; (b) assurance of receiving uniformly acceptable produce—specifically designed for frying, boiling, or mashing purposes; and (c) large reduction in the space formerly required for the bulk storage of unpeeled potatoes.

The present study is concerned with the evaluation of various chemicals used in the dipping solution as antidarkening and antimicrobial agents and with the effect of storage temperature on the keeping quality of the treated pre-peeled potatoes.

REVIEW OF THE LITERATURE

According to Treadway and Olson *(13)* pre-peeled potatoes were introduced into institutional channels over 20 years ago, but only since the end of World War II has the industry grown to its present status. Much research has been devoted to product improvement. An important phase of this research has been the effort to inhibit discoloration. Solutions of sulfur dioxide (SO_2) or its salts have been found to be among the most effective of chemical controls. Williams *(17)* recommended dipping peeled potatoes in a 2.0% sodium metabisulfite solution for approximately 10 minutes, to allow a concentration of more than 600 but less than 2000 p.p.m. of sulfur dioxide in the potato. Matarazzo *(8)* found that dipping the peeled potatoes for 5 to 30 seconds in aqueous solutions of sulfur dioxide ranging in concentration from 0.5 to 6.0% followed by storage at temperatures just above freezing would result in a product with a shelf-life of 10 to 30 days. Olson and Treadway *(11)* recommended, in a review of the subject, the following minimum treatments to prevent darkening of pre-peeled potatoes for a period of 10 to 15 days when stored in sealed containers at 40° F.: (a) a 15- to 30-second dip in 1.7% sodium bisulfite solution; (b) a 5-minute dip in 0.1 to 0.2% sodium bisulfite solution; and (c) a 10-minute dip in 0.5% sodium or potassium metabisulfite solution.

Kalmar, Kilburn and Pancoast *(6)* advocated a preliminary blanching (i.e., 90-second dip) of the peeled potatoes in boiling water before treating them for 30 seconds in an aqueous solution of 1.6% sodium metabisulfite. If stored at 38 to 42° F., potatoes treated in this manner would keep for 3 weeks or longer. Spraying the sulfited potatoes with an aqueous solution of citric, tartaric, or acetic acid was shown to enhance the preservative properties of the sulfite treatment.

[a] Contribution No. 957 Massachusetts Agricultural Experiment Station, U. of Mass., Amherst, Massachusetts.

[b] Presented at the Fourteenth Annual Meeting of the IFT, June 27, 1954, Los Angeles, California.

Although Li *(7)* obtained a storage life of up to 30 days at 40° F. after treating the peeled potatoes for 8 minutes in a solution containing 3000 p.p.m. of SO_2, Westcott *(16)* found that a 15-second dip in a solution of 10,000 p.p.m. of SO_2 was equally effective. In a patented process, Scalera *(12)* first dipped the peeled potatoes for one minute in an aqueous solution of sodium sulphite and citric acid containing from 6 to 8.5% SO_2, then trimmed, and finally redipped them in the same solution for another minute before storing them at 40° F. Dipping particles of fruits and vegetables in an aqueous solution of sodium bisulfite buffered in the pH range of 5.2 to 6.5 by means of citric acid and sodium carbonate was found to be an efficient method of preventing discoloration by Antle and Bohn *(2)*. Mullins, Olson and Treadway *(10)* reported two different dipping solutions as effective antidiscoloring agents: (a) a 30-second dip of the peeled potatoes in a 1.7% sodium bisulfite solution, or (b) a 30-second dip in a solution of 0.5% sodium bisulfite and 0.5% citric acid monohydrate.

Reporting on a commercial operation, Ziemba *(18)* found that pre-peeled potatoes were prepared by lye peeling, immersing first for 30 seconds in a 2% citric acid solution and then for 15 seconds in a 1.5% sodium bisulfite solution before packaging and storage at 40° F. The larger potatoes, intended for use as french fried potatoes, received an additional 15-second dip in the bisulfite solution after being sliced in ½-inch strips.

Chemicals other than sulfur dioxide or its salts have been tested. Jungerich *(5)* noted favorable results from 2 treatments: (a) immersion of the raw fruit or vegetable for 10 to 20 seconds in a boiling aqueous solution of at least 3.0% acetic acid and 0.85% sodium chloride; or (b) immersion of peeled potatoes for 15 to 20 minutes in an aqueous solution of 5.0% acetic acid and 0.85% sodium chloride at room temperature followed by dipping in boiling 1% sodium chloride solutions for 5 seconds. Dubois *(4)* maintained that ascorbic acid could also be used to preserve the color of peeled white potatoes.

EXPERIMENTAL

In investigating methods for preventing the discoloration of pre-peeled potatoes, preliminary studies in this laboratory, begun in 1949, were concerned with the effectiveness of various aqueous solutions of anhydrous sodium bisulfite in preventing discoloration both in refrigerated storage (32 to 40° F.) and at room temperature (65 to 75° F.). In these early trials, sodium bisulfite concentrations calculated to provide from 500 to 4,000 p.p.m. of SO_2 in the dipping solution were used. Thus, although a storage life of from 14 to 16 days was realized when the potatoes were packaged in quart jars, dipping times of from 2 to 10 minutes were required.

In succeeding studies, attempts were made to find a concentration of SO_2 in the dipping solution which would permit more rapid dipping treatments and therefore be more adaptable to commercial operations. It was found that after dipping for 15 seconds into an aqueous solution of sodium bisulfite calculated to contain 10,000 p.p.m. SO_2, pre-peeled potatoes could be stored at 32 to 40° F. for 2 to 3 weeks without spoilage or discoloration. Inasmuch as in commercial operations deliveries to consumers vary from as often as daily to once a week, treatments ensuring a total storage life of 14 days at 32 to 40° F. were considered as providing an adequate margin of safety. It also should be noted that if these storage temperatures of 32 to 40° F. are not maintained, the storage life is considerably shortened.

Effect of variety of potato and locale where grown. It was judged of interest to determine just how variable the storage lives of different varieties of potatoes and of the same variety grown in different areas would be after subjecting them to the standardized dipping treatment of 15 seconds in an aqueous solution of sodium bisulfite calculated to contain 10,000 p.p.m. SO_2 and storage at 32 to 40° F.

In cooperation with the Agronomy Department of the University of Maine, samples of Green Mountain, Katahdin, Chippewa and Kennebec varieties of potatoes were obtained; Green Mountain, Katahdin and Irish Cobbler varieties were secured from the University of Massachusetts.[6] After abrasion peeling, trimming, sulfite dipping, and packaging in quart jars in triplicate, the packs were stored at 35° F. and examined daily for discoloration.

All samples remained in good condition for 22 to 25 days; the Green Mountain potatoes grown in Massachusetts were still salable at the end of 30 days.

Effect of packaging sulfited potatoes immediately after dipping and after air drying. Studies were conducted to determine the effect on the keeping quality of pre-peeled potatoes packaged after a short drainage period (about 15 seconds) following the dipping treatment as compared to potatoes whose dipped surfaces were air dried by means of an electric fan before packaging. From the results listed in Table 1, it may be ascertained that

TABLE 1

Storage life of pre-peeled potatoes at 35 and 75° F. after dipping and draining 15 seconds and after dipping and air drying

Dipping solution	Time of dip	Storage life at			
		35° F.		75° F.	
		Wet [1]	Dried [2]	Wet	Dried
	Seconds	*Days*	*Days*	*Days*	*Days*
10,000 p.p.m. SO_2	15	25	10	2	2
10,000 p.p.m. SO_2 + 3% Calcium Propionate	15	6	6	2	2
10,000 p.p.m. SO_2 + 3% Disodium Acetate	15	21	21	2	2

[1] Wet, i.e., potatoes with 15-second drainage period.
[2] Dried, i.e., potatoes dried by the electric fan.

air-drying the pre-peeled potatoes caused little difference in the storage lives of those dipped in the standard 10,000 p.p.m. of SO_2 plus either 3.0% calcium propionate or 3.0% disodium acetate. The marked reduction of the storage life between the potatoes air dried after dipping in the standard 10,000 p.p.m. SO_2 solution and those packed shortly after dipping, is undoubtedly due to the loss of SO_2 occasioned by the air currents of the fan during the 3- to 5-minute drying period.

It is of interest that the storage lives at 35° F. of the pre-peeled potatoes dipped in the solution containing 10,000 p.p.m. SO_2 plus either the added calcium propionate or disodium acetate remained the same at 6 and 21 days, respectively, regardless of whether or not the potatoes were packaged "wet" or after air drying. This is in contrast to similar potatoes dipped in the standard 10,000 p.p.m. SO_2 solution which at 35° F. remained salable for 25 days when packaged "wet" but for only 10 days when packaged after air drying. At the time, this aspect of the problem was not investigated further nor was it determined why the storage lives of the pre-peeled potatoes were reduced when calcium propionate and disodium acetate were added to the 10,000 p.p.m. SO_2 dipping solution.

Efficiency of reducing agents and chemicals other than sodium bisulfite as antidiscoloration agents. In a search for chemicals other than those containing SO_2 that might prove effective when used in the dipping solution to prevent the discoloration of the pre-peeled potatoes, a variety of organic acids, reducing substances, and preservatives were evaluated. The results are presented in Table 2. It may be seen that none of the compounds tested would be effective commercially in preventing discoloration of pre-peeled potatoes, although treatments with thiourea, phosphoric acid and oxalic acid did have a slightly beneficial effect on the storage lives.

Inasmuch as Sequestrene Na_2 (disodium salt of ethylenediamine tetra acetic acid) and related compounds are capable of chelating iron and copper ions, it was thought advisable to experiment with these agents as possible replacements for SO_2 in the dipping solution.

Pre-peeled potatoes were dipped in aqueous solutions containing 50 to 200 p.p.m. of Sequestrene Na_2 and were also blanched up to 30 seconds in aqueous solutions containing as much as 5,000 p.p.m. of Versene or Versene Fe-3 Specific before packaging and storing at 35° F. In none of the above treatments did the storage life of the pre-peeled potatoes exceed 24 hours.

Effect of blanching on peeled unsulfited potatoes. Potatoes of uniform size were selected, peeled, and trimmed to a standard

[6] Courtesy of Prof. K. J. Kucinski, Agronomy Dept., Univ. of Massachusetts.

TABLE 2

Storage life at 35° and 75° F. of pre-peeled potatoes treated with various chemicals

Dipping solution	Time of dip	Storage life at	
		35° F.	75° F.
	Minutes	*Days*	*Days*
Control	None	0	0
10,000 p.p.m. SO_2	¼	25	2-4
10,000 p.p.m. SO_2 + 2.0% NaBenzoate	¼	14	3
0.1% L-cysteine	5	1	0
1.0% thiourea	5	4	2
1.0% m- phosphoric acid	2	2	0
1.0% oxalic acid	2	2	0
0.1% hydroxylamine	2	1	0
0.1% sorbic acid	2	0	0
2.0% disodium acetate	2	0	0
10% ascorbic acid	2	1-2	1
0.1% sodium benzoate	2	0	0
2.0% sodium benzoate	2	0	0

weight of 100 grams, corresponding to a potato approximately three inches long by two inches in diameter. The potatoes were then immersed in boiling water and at least two potatoes were removed at two-minute intervals up to a total of 12 minutes' blanching time. Upon removal, the potatoes were cooled in water and stored at 35° F. After four days' storage, the potatoes were removed and cut in half. The results of the various blanching tests are illustrated in Figure 1.

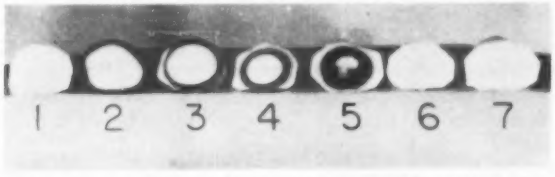

Figure 1. Effect of blanching on pre-peeled potatoes after four days' storage at 35° F.
Legend:

1 = Raw potato
2 = Blanched 2 minutes
3 = Blanched 4 minutes
4 = Blanched 6 minutes
5 = Blanched 8 minutes
6 = Blanched 10 minutes
7 = Blanched 12 minutes

In an attempt to minimize discoloration by excluding air from the blanched surfaces of the potatoes, several lots were dipped in a melted hydrogenated shortening immediately after blanching for two minutes. Pre-peeled potatoes treated in this manner discolored as rapidly as the untreated samples.

As can be seen from Figure 1, for the size of potato used, at least 10 minutes' blanching in boiling water is required to prevent discoloration. The impracticability of this procedure is obvious. Not only are the potatoes partially cooked, but they become rubbery in texture during storage. In addition, there would be the necessity of grading the potatoes and blanching the larger potatoes longer times than the smaller ones.

Regulated release of SO_2 to pre-peeled potatoes. Earlier investigations demonstrated that pre-peeled potatoes dipped in a solution containing 10,000 p.p.m. of SO_2 would have a shelf-life of about three weeks at 35° F. but only two to four days at 75° F. Apparently, the SO_2 is oxidized and, therefore, inactivated by the potato tissue and surrounding air. Obviously, this occurs much more rapidly at 75° F. than at 35° F.

In an attempt to extend the shelf-life of the pre-peeled potatoes at 75° F., an adaptation of the method prescribed by Van der Plank *(15)* and Van der Plank and Van Wyk *(16)* for the storage of grapes was employed. This method consisted of providing for a regulated release of SO_2 from a small envelope containing a sulfite salt mixed with an acidic, hygroscopic salt which was placed within the grape package.

Heat-sealed envelopes about one-inch square were prepared from 0.0015 inch polyethylene film. Various proportions of sodium metabisulfite and anhydrous aluminum sulfate were placed in the polyethylene envelopes so that each envelope contained the equivalent of 0.5 grams of SO_2.

In one series of experiments, the potatoes were peeled and dipped for 60 seconds in an aqueous solution containing 5000 p.p.m. of SO_2 before being packed into quart glass jars (both sealed and unsealed) and into polyethylene bags. The envelopes containing the metabisulfite-aluminum sulfate mixtures were then added and the samples stored at room temperature (75° F.). In the second series of experiments, only the preliminary dip in the 5,000 p.p.m. of SO_2 solution was eliminated. The results of these tests are found in Tables 3 and 4.

From the data presented in these tables, it appears evident that the application of Van der Plank's method to pre-peeled potato operations would not be feasible from a commercial point of view. It appeared as though any SO_2 that was released from the envelopes reacted locally with adjacent potato tissue rather than diffusing throughout the packages and giving an overall protective effect. The potatoes nearest to the envelopes became markedly bleached and soggy while the other potatoes were as susceptible to fermentation and discoloration as the control potatoes.

Effect of sulfiting on the thiamine content of whole and french fried types of pre-peeled potatoes during storage at 38° F. Inasmuch as it is a well-established fact that sulfite destroys both thiamine and its principal ester, cocarboxylase, experiments were set up to determine how much thiamine was destroyed in the recommended sulfiting treatment of pre-peeled potatoes and their subsequent storage.

At the time of this study, samples of both "old" Maine (Katahdin variety) and "new" Florida potatoes (Sebago variety) were available, thereby enabling the determination of differences of thiamine, if any, between these potatoes.

Representative samples of each variety were abrasion peeled, trimmed, dipped for 15 seconds in an aqueous sodium bisulfite solution containing 10,000 p.p.m. of SO_2, drained and packaged into polyethylene bags. Five-pound samples of french fried potatoes were prepared from each variety. All samples were then stored at 38° F. until analyzed.

Thiamine analyses were carried out in accordance with the procedure outlined by the Association of Vitamin Chemists *(3)* as modified by Moyer and Tressler *(9)* using a Coleman Model 12B Universal Spectrophotometer. With the whole potatoes for each analysis, wedge-shaped pieces were taken from the periphery to the center of at least 6 tubers, and 10 randomly selected pieces were selected for the analysis of the french fries. Calcu-

TABLE 3

Storage life of sulfited pre-peeled potatoes at 75° F. in various packages containing regulated supply of SO_2

Container	Contents of Polyethylene envelope	Storage life	Observations
		Days	
Glass jar—unsealed	Control	3	No discoloration—fermented—mold growth
Glass jar—unsealed	0.5 gm. SO_2	3	No discoloration—fermented—mold growth
Glass jar—unsealed	1:1 $SO_2/Al_2(SO_4)_3$	2	No discoloration—mold growth—potatoes bleached near envelope
Glass jar—unsealed	1:3 $SO_2/Al_2(SO_4)_3$	2	No discoloration—mold growth—potatoes bleached near envelope
Glass jar—sealed	Control	4	No discoloration—fermented—mold
Glass jar—sealed	0.5 gm. SO_2	3	No discoloration—fermented—mold
Glass jar—sealed	1:1 $SO_2/Al_2(SO_4)_3$	3	No discoloration—fermented—mold—potatoes bleached near envelope
Glass jar—sealed	1:3 $SO_2/Al_2(SO_4)_3$	3	No discoloration—fermented—mold—potatoes bleached near envelope
Polyethylene bag	Control	2	No discoloration—fermented—some mold
Polyethylene bag	0.5 gm. SO_2	2	No discoloration—fermented—some mold
Polyethylene bag	1:1 $SO_2/Al_2(SO_4)_3$	3	No discoloration—fermented—bleaching of potatoes near envelope
Polyethylene bag	1:3 $SO_2/Al_2(SO_4)_3$	3	No discoloration—fermented—bleaching of potatoes near envelope

TABLE 4

Storage life of untreated pre-peeled potatoes at 75° F. in various packages containing a regulated supply of SO_2

Container	Contents of Polyethylene envelope	Storage life	Observations
		Days	
Glass jar—unsealed	Control	0	Some discoloration
Glass jar—unsealed	0.5 gm. SO_2	0	Some discoloration
Glass jar—unsealed	1:1 $SO_2/Al_2(SO_4)_3$	2	Some discoloration—potato bleached near envelope
Glass jar—unsealed	1:3 $SO_2/Al_2(SO_4)_3$	2	Some discoloration—potato bleached near envelope
Glass jar—sealed	Control	1	Slight discoloration—some mold
Glass jar—sealed	0.5 gm. SO_2	5	No discoloration—wet near envelope
Glass jar—sealed	1:1 $SO_2/Al_2(SO_4)_3$	4	No discoloration—potatoes bleached near envelope
Glass jar—sealed	1:3 $SO_2/Al_2(SO_4)_3$	4	No discoloration—potatoes bleached near envelope
Polyethylene bag	Control	1	Discoloration, molds
Polyethylene bag	0.5 gm. SO_2	1	Discoloration, molds
Polyethylene bag	1:1 $SO_2/Al_2(SO_4)_3$	2	Discoloration, mold, potatoes bleached near envelope
Polyethylene bag	1:3 $SO_2/Al_2(SO_4)_3$	1	Discoloration, mold, potatoes bleached near envelope

lations of the thiamine content were made against a standard thiamine solution, which was carried through the entire thiochrome procedure. Analyses were made immediately after dipping and at 24-hour intervals for five days and again at the end of eight days.

It is apparent from Table 5 that there is less thiamine loss with the whole potatoes than with the french fries. Although, in 8 days' storage at 38° F. the pre-peeled whole Maine Katahdin (old) and the Florida Sebago (new) varieties lost only 11 and 13%, respectively, of their thiamine content, these same varieties of potatoes prepared as pre-peeled french fries lost 47 and 30% of their original thiamine content. These results were not unexpected inasmuch as the proportion of sulfited surface area to potato area is much greater with the french fries than with the whole potatoes.

TABLE 5

Thiamine content per 100 grams of untreated and sulfited pre-peeled old and new, whole and french fried style potatoes during storage at 38° F.

Type of potato	Thiamine Content/100 grams (wet basis)						
	Days' storage at 38° F.						
	0	1	2	3	4	5	8
	Micrograms						
Old,[1] Treated, Whole	92	92	78	86	86	88	82
New,[2] Treated, Whole	76	67	54	70	66	68	66
Old, Treated, F. F.	87	77	61	52	57	54	46
New, Treated, F. F.	64	64	46	54	49	50	45

[1] Maine Katahdin variety.
[2] Florida Sebago variety.

SUMMARY AND CONCLUSIONS

When packed in polyethylene bags and stored at temperatures of 32 to 40° F., pre-peeled potatoes, either whole or french fried, will have a storage life of approximately three weeks if pre-treated by immersion for 15 seconds in an aqueous solution of sodium bisulfite calculated to contain 10,000 p.p.m. SO_2. Longer immersions in solutions containing less SO_2 accomplished the same results.

Under the experimental conditions, there was little or no difference in the storage life at 35° F. of different varieties of potatoes or of the same variety grown in different locales after treatment with recommended sulfite dipping solutions.

As might be anticipated, the net result of air drying sulfited pre-peeled potatoes before packaging resulted in a shorter shelf life than was the case with comparable potatoes packaged after only a 15-second drainage period.

None of the chelating agents, organic acids, reducing or antimicrobial compounds evaluated in this investigation yielded shelf lives for pre-peeled potatoes that compared favorably with those obtained from the sulfite treatment.

In attempts to develop an antidarkening treatment which, in combination with antimicrobiological agents, might permit sale of pre-peeled potatoes at room temperature, no success was obtained.

Blanching studies on selected medium-sized whole potatoes indicated that approximately 10 minutes in boiling water were required to destroy all enzymatic activity and resultant discoloration. For many reasons this procedure is not considered economically feasible.

The use of a regulated release of SO_2 in an attempt to prolong the storage life of pre-peeled potatoes at room temperature did not prove satisfactory.

After 8 days' storage at 35° F., the recommended dipping procedure of 15 seconds in a solution containing 10,000 p.p.m. of SO_2 was found to bring about 11 to 13% losses in the thiamine content of whole pre-peeled potatoes and from 30 to 47% losses in the french fries.

Acknowledgments

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LITERATURE CITED

1. Anonymous. Processed foods are raising rate of potato consumption. *Food Field Reporter*, **22** (4), 9 (1954).
2. Antle, L. L., and Bohn, R. M. Method of preventing discoloration of sliced organic materials. U. S. Patent 2,628,905 (1953).
3. Association of Vitamin Chemists, Inc. *Methods of Vitamin Assay*. 1951, Interscience Publishers, Inc., New York, N. Y.
4. Dubois, C. W. Ascorbic acid and color in food products. *Food Technol.*, **3**, 119 (1949).
5. Iungerich, F. L. Food Preservation. U. S. Patent 2,472,017 (1949).
6. Kalmar, A. F., Kilburn, R. W., and Pancoast, H. M., Jr. Method of producing fresh whole peeled potato products. U. S. Patent 2,506,793 (1950).
7. Li, K. C. Pre-peeled white potatoes for institutional consumers. (Master's thesis, University of Massachusetts, 1950.)
8. Matarazzo, R. F. Preserving peeled white potatoes. U. S. Patent 2,420,322 (1947).
9. Moyer, J. C., and Tressler, D. K. Determination of thiamine in vegetables. *Ind. Eng. Chem., Anal. Ed.*, **14**, 788 (1942).
10. Mullins, W. R., Olson, R. L., and Treadway, R. H. Control of discoloration of peeled white potatoes and methods for analysis of treating solutions. U. S. D. A. *Bull. AIC-360*, 8 pp. (1953).

11. Olson, R. L., and Treadway, R. H. Pre-peeled potatoes for commercial use. U. S. D. A. *Bull. AIC-246*, 14 pp. (1949).
12. Scalera, C. Preserving peeled white potatoes. U. S. Patent 2,620,277 (1952).
13. Treadway, R. H., and Olson, R. L. Pre-peeled potatoes—treatment and packaging. *Pre-Pack-Age*, **7** (4), 13 (1953).
14. Van der Plank, J. E. A device for the regulated release of sulfur dioxide in packages of stored table grapes, Union S. Africa, Dept. Agr. Forestry, Ann. Rept. Low Temp. Research Lab., Capetown 1937-38, 76-78 (1939). *C. A.*, **34**, 2945.
15. Van der Plank, J. E., and Van Wyk, G. F. The preparation of tablets for the release of sulfur dioxide in packages of stored table grapes. Union S. Africa, Dept. Agr. Forestry, Ann. Rept. Low Temp. Research Lab., Capetown 1938-39, 43-47 (1940). *C. A.*, **35**, 1134.
16. Westcott, D. E. Prevention of discoloration of pre-peeled potatoes. (Master's thesis, University of Massachusetts, 1951.)
17. Williams, J. L. Process of treating peeled potatoes. U. S. Patent 2,241,436 (1941).
18. Ziemba, J. V. Potato peeling spurts on continuous, company-built production line. *Food Eng.*, **26** (5), 92 (1954).

Degree of Heat-Inactivation of Polyphenol Oxidase and Quality of Frozen Apricot Puree

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Samples of apricot puree from one lot of fruit were given various heat treatments with respect to time and temperature, in a tubular heater, and then frozen and stored for 3, 6, and 12 months at four different sub-freezing temperatures. After storage, the purees were thawed and judged organoleptically. Polyphenol oxidase activity was measured before and after heating and after storage. It was found that the best quality of puree was obtained by heating just enough to completely inactivate the polyphenol oxidase. Less heating allowed rapid browning to occur on thawing and resulted also in an oxidized flavor, while excessive heating caused a cooked and sometimes bitter flavor. However, a mild cooked flavor was not objectionable.

The enzyme polyphenol oxidase has been shown to be important in the browing of apricots as well as of many other fruits [Ponting and Joslyn *(2)*]; and Dimick, Ponting, and Makower *(1)* have determined approximate heat processing conditions for essentially complete inactivation of polyphenol oxidase in apricot and other fruit purees. However, the problem of selection of the best conditions for heat treatment gives rise to several questions: Must the inactivation of polyphenol oxidase be complete to insure a satisfactory color and flavor in the puree after freezing and thawing? What limits of underheating and overheating are permissible without affecting organoleptic quality? How is the organoleptic quality of the puree affected by the temperature chosen for the inactivation process? Also, how do time and temperature of frozen storage affect quality of the puree? The experiments reported in this paper were undertaken in an effort to provide answers to these questions.

Apricot puree was subjected to varying times and temperatures of heating which included insufficient, as well as more than sufficient, heat treatment for inactivation of polyphenol oxidase. The residual enzyme activity, if any, was measured, the puree was frozen and held for various times and at various temperatures in frozen storage, then samples were thawed and judged organoleptically for color, flavor, and aroma. Polyphenol oxidase activity was remeasured at this time to observe any change in enzyme content caused by storage conditions. In this way it was possible to correlate quality of puree with residual polyphenol oxidase activity and heating and storage conditions.

EXPERIMENTAL

All experiments were made with one lot of apricots from the Santa Clara valley in California. These were late-season apricots of highly variable maturity. The fruit was washed, pureed in a screw-feed pulper through a screen having holes 0.027 inch in diameter, and deaerated in batches of 5 to 8 pounds in a small, high-speed centrifugal deaerator under a vacuum of approximately 29 inches of mercury. It was then heat-processed in an apparatus of the same type as that described by Dimick *et al. (1)* but with several modifications designed to increase heating efficiency.

The puree was pumped at a constant rate through an 0.087-inch I. D. stainless-steel, steam-jacketed preheating tube 6 feet long followed by a glass holding tube and a stainless-steel water jacketed cooling tube. Five holding tubes were used, to give holding times of 5, 10, 20, 30, and 60 seconds. These holding tubes were interchangeable spirals with varying lengths but the same inside diameter (approximately ¼ inch). To insure a uniform holding temperature the tubes were immersed in a constant-temperature water bath regulated to maintain the temperature attained by the puree in the stainless-steel heating tube. The time required for passage of puree through the heating tube was approximately 1 second, which could be neglected in calculating most of the holding times. The time required to cool the puree below enzyme-inactivating temperature after holding was also negligible.

Processing experiments were grouped in three series. In series A, heating temperature and holding time were barely adequate to inactivate all the polyphenol oxidase (A_1). The temperature was then raised 5° C. (9° F.) for A_2 and 10° C. (18° F.) for A_3 at the same holding time to determine the effect on quality of overheating in this manner. The minimum time of heating at a certain temperature required to inactivate the enzyme was determined by heating samples for gradually increasing times, starting with a time which left some enzyme still active. Series B compared a relatively high-temperature, short-time process (B_1) with a lower-temperature, longer-time process (B_2), and both were compared with a raw sample packed with

0.1% ascorbic acid (B_1). B_2 and B_3 were both heated just sufficiently to inactivate the polyphenol oxidase completely. In series C the polyphenol oxidase was inactivated only partially in two samples (C_1 = 67 to 79%, C_3 = 89 to 96% inactivation); in one sample (C_2) it was just inactivated completely; and in one sample (C_4) the holding time was doubled at the same temperature used for C_3 in order to ascertain the effect of heating longer than necessary for inactivation.

Sufficient puree of each individual lot within a series was packed to allow storage of samples at 4 temperatures for 3 storage times. The storage temperatures were —30°, —10°, 0°, and + 10° F. (—34°, —23°, —18°, and —12° C.) and the storage times were 3, 6, and 12 months. Samples were removed from storage at these intervals, for organoleptic quality tests and polyphenol oxidase activity, viscosity, and pH measurement. Color and rate of darkening were also measured on certain puree samples by means of a Hunter color difference meter.

Polyphenol oxidase activity was measured in the raw deaerated puree and immediately after processing to determine the percentage inactivation of the enzyme. The method of measurement was based on that described by Ponting and Joslyn *(2)* in which the rate of darkening of catechol by the extracted enzyme is measured in a photoelectric colorimeter. The extract was prepared by blending 50 g. of puree with 150 g. of ice-cold 2% sodium carbonate solution for 3 minutes, then filtering through a cotton milk filter disk. This extraction procedure was found to give consistent values for enzyme activity in the extract; also when the enzyme was shown to be barely inactivated by the colorimetric test on the extract, a spot test of the puree with catechol was likewise negative.

RESULTS

A preliminary survey of the organoleptic characteristics of the various samples indicated that puree which had been overheated had a "cooked" flavor and aroma similar to canned fruit, and also what was considered by some tasters to be a bitter flavor. On the other hand, puree in which polyphenol oxidase had not been inactivated completely had a flavor and aroma similar to that of fresh fruit which has been crushed and allowed to brown by oxidation. This was called "oxidized" flavor or aroma.

In the first organoleptic evaluations, after 3 months' frozen storage, members of a taste panel of about 12 people were asked to note whether they could detect a cooked or oxidized flavor or aroma or bitterness in the samples. The results of these tests for puree stored at —30° F. are shown in Tables 1, 2, and 3. Results for aroma are not given in the tables in the interest of brevity, since they closely paralleled the results for flavor. Conclusions as to quality were made in a general way from the preponderance of tasters who detected one or another of the above-described "off" flavors.

Since little change might be expected to occur in storage at —30° F., the results of this storage series are assumed to represent the initial quality of the purees as originally prepared for storage studies.

Organoleptic evaluation at the end of 6 and 12 months' frozen storage was not made by the same taste-panel method used after 3 months' storage. These purees were evaluated by a panel of 8 or 9 people who were experienced tasters, in group tastings. A complete series (that is, samples representing all the different storage temperatures) were tasted at the same time and compared with one another in quality. Judges were first asked to write down their comments and then these were discussed. By this method conclusions were reached as to the most desirable puree, and differences among puree samples, if any. Since these conclusions in general confirmed the results of initial organoleptic tests, the latter will be discussed more fully below, as related to individual variables.

TABLE 1
Effect of overheating on quality of apricot puree

Code No.	Time heated, sec.	Temp. heated, ° C.	Color and flavor of product [1]	
			Color	Flavor
A_1	60	86 [2]	bright	bitterness and cooked flavor slight [3]
A_2	60	91	bright	bitterness and cooked flavor slight [3]
A_3	60	96	bright	more bitterness and cooked flavor than A_1, A_2

[1] No significant oxidized flavor was noted in these samples.
[2] Sample A_1 heated just enough to inactivate polyphenol oxidase; samples A_2 and A_3 were overheated.
[3] Slight bitterness and cooked flavors in A_1 and A_2 were not considered objectionable by the taste panel.

TABLE 2
Effect of conditions of heating on quality of apricot puree

Code No.	Time heated, sec.	Temp. heated, ° C.	Percent inactivation of polyphenol oxidase	Color and flavor of product	
				Color	Flavor
B_1	0	13	13	Brown	oxidized
B_2	60	86	100	Bright	slight bitterness and cooked flavor
B_3	10	90	100	Bright	slight bitterness and cooked flavor

TABLE 3
Effect of degree of heating and enzyme inactivation on quality of frozen apricot puree

Code No.	Time heated, sec.	Temp. heated, ° C.	Percent inactivation	Color	Flavor
C_1	5	70	60	very brown	oxidized
C_2	5	80	95	brown	oxidized
C_3	10	90	100	bright	very slight cooked flavor, best of four
C_4	20	90	100	bright	slight bitter, cooked flavor

DISCUSSION

Effect of overheating. In the A series (Table 1), overheating by 5° C. (A_2) does not appear to have altered the quality appreciably, but overheating by 10° C. (A_3) caused a definite increase in cooked aroma and flavor. In the C series (Table 3), C_3 was heated just enough to inactivate all the polyphenol oxidase and C_4 was heated twice as long as C_3 at the same temperature. With this type of overheating, there also was little change in quality, although in both C_3 and C_4 the tasters detected some cooked flavor (slightly more in C_4 than C_3).

Effect of processing temperature. The B series is an experiment comparing the effect of relatively low-temperature, long-time heating with relatively high-temperature, short-time heating, in each case heating just enough to inactivate all the polyphenol oxidase. The results are shown in Table 2. B_2 was heated at 86° C. (187° F.) for 60 seconds and B_3 was heated at 90° C. (194° F.) for 10 seconds. With this range of time and temperature there was no significant difference in quality. However, it is possible that in other equipment, capable of heating for 1 second or less, there would be a noticeable difference. Sample B_1 was not heated but packed with 0.1% ascorbic acid. This was not enough ascorbic acid to prevent enzymic oxidation of the puree after thawing.

Effect of incomplete inactivation of polyphenol oxidase. In Table 3 it may be seen that samples C_1 and C_2, in which the polyphenol oxidase was inactivated

to the extent of 67 to 79% and 89 to 96%, respectively, both had browned and had an oxidized flavor. Samples C_3 and C_4, which contained no residual enzyme activity, did not have an appreciable oxidized flavor. It is interesting that sample C_2 had about as much oxidized flavor as sample C_1, although it contained only about one-fourth as much residual enzyme activity. This indicates that polyphenol oxidase must be removed almost completely to prevent oxidized flavor and darkening.

Effect of storage time and temperature. Results obtained at the end of 6-months and 1-year storage periods were similar in general to the initial results given in the tables. Different storage temperatures also had little effect on organoleptic quality. No differences were apparent in the A series after 1 year. A triangle test comparing sample B_3 stored at —30° F. and 0° F. for 1 year showed the differences were not significant. In the C series differences were fairly evident in under-flavor at higher storage temperatures, but differences heated puree, C_1 showing more browning and oxidized due to storage temperature were scarcely detectable in samples C_3 and C_4, in which polyphenol oxidase was completely inactivated.

Effect of heating conditions on color. The color of puree samples after thawing paralleled very closely the results of organoleptic taste tests and enzyme activity analyses. All samples in which the polyphenol oxidase had been inactivated completely had an apparently natural color to the eye after thawing. Samples C_1 and C_2 both browned rapidly, even though C_2 contained only about 5% of its original enzyme activity.

Figure 1 shows the rate of darkening of samples C_2 and C_4, as measured in the Hunter color difference meter. Puree was poured into Petri dishes and total darkening was measured at intervals by measurement of reflectance from the surface of the puree, with Munsell paper YR 6/12 as a standard. It may be seen that C_2 darkened much more rapidly than C_4 at first; then the rate of darkening decreased gradually. This is is a typical curve of enzymic browning, the half-time being about 9 minutes. C_4 also showed some darkening even though the puree had been heated twice as long as required to inactivate all the polyphenol oxidase. However, in this case the darkening was slow and linear and the curve is not typical of enzymic darkening. The darkening may be due to drying out of the surface layer.

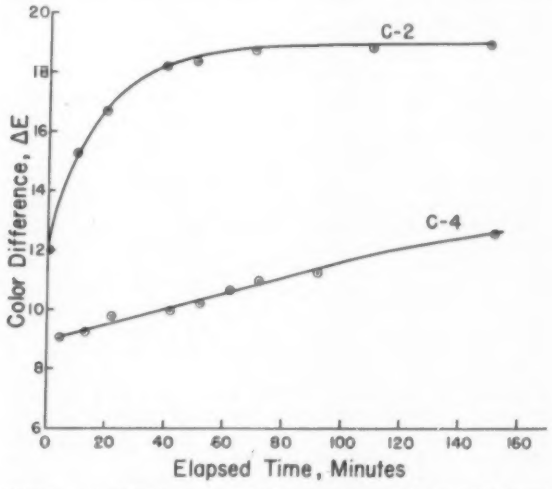

Figure 1. Darkening of apricot puree measured by reflectance.

Viscosity and pH. Viscosity and pH measurements were made on all the processed samples, but there were no consistent differences. Relative viscosity varied irregularly between 1.7 and 2.5 while pH varied, also irregularly, between 3.70 and 3.80. The pH of the raw puree was 3.66. The increase in pH due to heating was noted previously in apricot and other purees by Dimick, Ponting, and Makower *(1)*.

SUMMARY AND CONCLUSIONS

Results of organoleptic judging indicate that the best apricot puree is that in which the polyphenol oxidase is inactivated completely, without any heating beyond the point of adequacy for inactivation. Within the conditions investigated, a relatively high-temperature, short-time process (90° C., or 194° F. for 10 sec.) was not significantly better than a relatively low-temperature, long-time process (86° C., or 186.8° F. for 60 sec.) when the polyphenol oxidase was barely, but completely, inactivated in each case. Heating more than necessary to inactivate the enzyme produced a cooked flavor and aroma, although these were not especially objectionable if mild. Even a slight under-inactivation of the enzyme (95% inactivation) allowed the puree to brown rapidly after thawing and develop an oxidized flavor and aroma. Therefore, conditions for preventing "oxidized" flavor and browning must be defined much more stringently than those conditions required to prevent the "cooked" flavor. Temperature and length of time of frozen storage, within the limits of this investigation, had little effect on quality.

Acknowledgment

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LITERATURE CITED

1. Dimick, K. P., Ponting, J. D., and Makower, B. Heat inactivation of polyphenolase in fruit purees. *Food Technol.*, 5, 237-41 (1950).
2. Ponting, J. D., and Joslyn, M. A. Ascorbic acid oxidation and browning in apple tissue extracts. *Arch. Biochem.*, 19, 47-63 (1948).

Consistency of Pastes and Puree from Pearson and San Marzano Tomatoes

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Pearson and San Marzano tomatoes were grown and then processed into pastes and purees by hot break and activated cold break processes. The consistency of these samples at different soluble solids content was evaluated by Stormer viscosimeter and Bostwick consistometer. In addition to these methods, commercial pastes were evaluated by the plate spreading method, serum viscosity, and rate of filtration of the diluted serum. These data were then correlated with uronide and solids contents of the samples.

The results indicate that San Marzano and mixtures of San Marzano and Pearson tomatoes produce purees and pastes of better consistency than do Pearsons alone. Pearson gave paste of commercially acceptable consistency as long as there was efficient and rapid heat inactivation of the pectic enzymes.

Consistency is one of the factors influencing the quality and marketability of macerated tomato products. The importance of pectic substances in determining consistency of tomato juice has been demonstrated by Kertesz and Loconti *(6)*, and of paste by McColloch, Keller, and Beavens *(11, 13)*. On the other hand, Underwood *(17)* has demonstrated that solids content in tomato paste has only a minor influence. Quick inactivation of pectic enzymes at 185° F. or higher to obtain paste of high consistency has been shown to be necessary by McColloch *et al. (13)*. Two general commercial processes are employed in the manufacture of tomato products *(13)*. In the "hot break" process the tomatoes are macerated at a temperature of 185° F., or higher; in the "cold break" process, the tomatoes are macerated at some temperature below 185° F., at which pectin esterase (PE) and depolymerase (DP) remain active *(6, 12, 13)*. The action of DP is primarily responsible for the breakdown of pectic substances which results in low consistency of tomato products. DP is more stable to heat than PE and is usually not completely inactivated at preheating temperatures. However, the action of DP on hydrolysis of pectin is dependent on the action of PE to form its substrate, pectinic acid or pectic acid, from the pectin of the tomato fruit. Thus, efficient inactivation of PE inhibits the action of DP in tomato processing and prevents losses in pectic substances. In commercial practice the "hot break" process is used in making tomato paste, and other products where a thick consistency is desirable, while the controlled "cold break" process is used for tomato products in which thick consistency is not a sales advantage.

The variety of tomato also affects tomato paste consistency. In California, Pearson (round) is the variety most extensively grown for canning, whereas the San Marzano (pear-shaped), in combination with Pearson is preferred in the manufacture of concentrated tomato products. Luh, Leonard, and Dempsey *(9)* investigated the quality and quantity of pectic substances in Pearson and San Marzano tomatoes and found the Pearson to have a lower pectin content. Investigations of tomato pectin have also been reported by Hamson *(3)*, Kassab *(4)*, Kertesz and McColloch *(7)*, and Saywell and Cruess *(15)*.

Literature on physical methods for measuring consistency of foods is quite abundant *(1, 5, 6, 13, 16, 17, 18, 19)*. Those methods applicable to tomato products are based on the use of the Bostwick consistometer *(19)*, Brookfield viscosimeter, Stormer viscosimeter *(6)*, penetrometer *(18)*, Jacobs gel-time viscosimeter *(11)*, and rate of filtration of the diluted paste *(13)*. In the case of high-solids pastes (46% total solids), which are much more viscous than those with 25% total solids, most of the consistometers mentioned cannot distinguish between samples produced by the "hot break" process from those by "cold break" process.

To study the effect of variety, pectic enzyme inactivation, and retention of pectic substances on consistency, purees and pastes from Pearson, San Marzano, and mixtures of the two were prepared by "hot break" and "activated cold break" processes. The consistency of the concentrates was measured by Bostwick and plate consistometer and Stormer viscosimeter. The results were then correlated with the pectin and solids contents. For comparison, a series of commercial tomato pastes was also investigated.

EXPERIMENTAL

Tomato fruits. Eighty tomato plants of each variety were transplanted to the field at the University farm at Davis in May, 1953. About 200 pounds of each variety of ripe tomatoes, fully red in color and of prime canning quality, were harvested. These were processed as described below. All cracked or blemished tomatoes and extraordinarily large or small fruits were removed.

Hot break (HB) process. The tomato fruits were washed and added gradually to 15 pounds of boiling distilled water in a steam-jacketed stainless steel kettle. The fruits were immediately disintegrated into the boiling puree. The mixture was boiled for 15 minutes after the last fruits had been added and then made up to the original weight with distilled water. The macerated tomatoes were pulped through a .033-inch screen in a pilot-scale pulper to remove skin and seeds. The macerate was evaporated at atmospheric pressure to purees and to pastes of different soluble-solids content as determined by refractive index measurements. The samples produced in this manner were filled into No. 2½ cans, sealed at 90° C., heated for 15 minutes in boiling water, and then rapidly cooled in running cold water.

Activated cold break (ACB) process. The term "activated cold break" is used here to designate a process in which the tomatoes are macerated within temperature ranges most conducive to pectic enzyme action. The washed tomato fruits were placed in a perforated steel basket and dipped into boiling water for exactly 2 minutes. They were then pulped through a .033 inch screen to remove the skins and seeds. The extracted juice from Pearson reached a temperature of 42° C. while that from San Marzano reached 51° C. To insure maximum degradation

of pectic substances, the warm juices were allowed to stand for 2 hours and then heated rapidly to boiling in a steam-jacketed stainless steel kettle. Purees and pastes of different soluble-solids contents were canned by the same method as described in the HB process.

Stormer viscosimeter *(2, 6)*. Stormer readings of tomato paste samples were taken after diluting with distilled water to approximately 9°, 10°, and 11° Brix soluble solids. Ninety ml. of the diluted samples were placed in the compartment which was surrounded by a water bath kept at 28° C. The time in seconds for 100 revolutions, with a driving weight of 165 g., was recorded. The exact Brix readings of the diluted samples were also recorded. The Stormer value at exactly 10° Brix was then interpolated. The reading for distilled water at 28° C. was 4.0 seconds.

Bostwick consistometer *(19)*. The sample was poured into the compartment and leveled. The extent of flow in cm. 30 seconds after releasing the gate was noted. The samples were at 25 ± 1° C.

Plate consistometer. A 6-oz. can with both ends removed was placed on a flat plastic plate marked with 9 concentric circles differing in radii by half an inch between successive circles. The average spread at four opposite sides, 30 seconds after lifting the container, was recorded. As with the Bostwick, a high reading indicates poor consistency. Measurements were made at 25 ± 1° C.

Rate of filtration *(13)*. A mixture of 10 g. of sample and 50 ml. of water was filtered through 15 cm. Whatman No. 1 filter paper in a 60° glass funnel. The volume of the filtrate at the end of 30 minutes was then recorded.

Diluted serum viscosity. The viscosity of the filtrate remaining from the rate-of-filtration determination was measured in a 5 ml. Ostwald viscosimeter at 29.4 ± 0.1° C. The value for water was 77.8 seconds.

Determination of pectic substances. The pectin content of the samples was determined by the carbazole method described by McCready and McComb *(14)*, using versene and pectinase to extract the pectic materials from pulp precipitated with 80% alcohol (final alcohol concentration of 63%). Twenty g. of the well-mixed sample were weighed into a 150 ml. beaker. Then 70 ml. of 80% ethyl alcohol and 0.6 ml. of 6 N HCl were added. The mixture was stirred, covered with a watch glass, and then heated on the steam bath for half an hour. The material was centrifuged at 1500 r.p.m. (600 × gravity) for 20 minutes and the resulting supernatant decanted into a Whatman No. 2 filter paper in a Buchner funnel under slight suction. The precipitate was mixed with 80 ml. of 63% ethyl alcohol in 0.05 HCl, stirred well, and centrifuged again for 20 minutes. The supernatant was poured through the same filter under suction. The precipitate was washed successively 3 times on the paper with 15 ml. portions of purified ethyl alcohol *(14)*. Then the pectic material was extracted from the precipitate with 200 ml. of 0.5% versene, de-esterified with NaOH at pH 11.5 for 30 minutes at room temperature, acidified to pH 5.0 with 1 N acetic acid, and then treated with 2 ml. of freshly prepared and filtered 10% pectinase solution in water (w/v). The mixture was allowed to stand overnight at room temperature, diluted to 250 ml. in a volumetric flask, and filtered through Whatman No. 1 filter paper. Ten ml. of the filtrate were diluted to 250 ml. Two ml. aliquots of the diluted sample were used for determination of galacturonic acid by the carbazole method as described by McCready and McComb *(14)*. A blank was run using all the reagents except the sample. One microgram of galacturonic acid monohydrate is equivalent to 0.83 microgram of anhydrouronic acid. The pectin content was reported as % anhydrouronic acid.

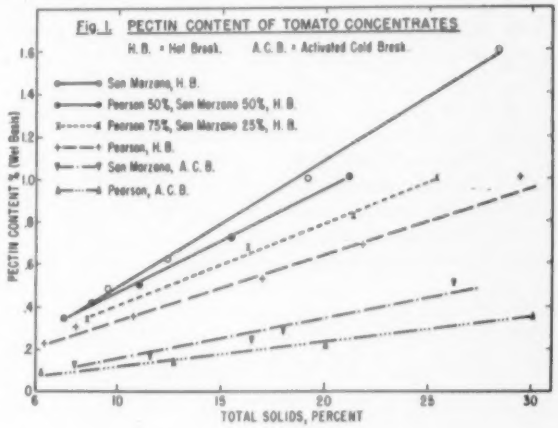
Soluble solids. A Zeiss Opton refractometer was used to determine soluble solids. Readings were corrected to 20° C.

Total solids. Ten to 20 g. of the sample were weighed accurately into tared aluminum dishes. The sample was mixed with distilled water to form a uniform layer, heated on a steam bath for 5 to 10 minutes ,and then dried for 8 hours at 70° C. under 27 inches of vacuum and a slow stream of dried air.

Alcohol-insoluble solids. Twenty g. amounts of the prepared samples were mixed with 200 ml. of 63% ethanol-water mixture made 0.05 N with HCl, vigorously stirred, covered with a watch glass, and then heated on a steam bath for 30 minutes. The precipitate was filtered on a previously weighed 9 cm. Whatman No. 2 filter paper in a Buchner funnel under suction, washed twice with 63% ethanol in 0.05 N HCl, twice with 95% ethanol, transferred to a weighed aluminum dish, and dried overnight at 70° C. under 27 inches of vacuum and a slow stream of dried air *(13)*.

RESULTS AND DISCUSSION

Pectin contents of purees and pastes. The pectin content of purees and pastes made from Pearson, San Marzano, and various combinations of the two are plotted against total solids content in Figure 1. Results on samples made from both "hot break" (HB) and "activated cold break" (ACB) processes are presented for comparison. The unconcentrated San Marzano pulp has a higher total pectin content than Pearson, confirming our previous work *(9)*. A 26% total-solids content paste made from San Marzano by the HB process has a total pectin content of 1.44% on the wet basis, whereas that from Pearson has a value of only .82%. Samples from mixtures of the two have an intermediate pectin content. Marked losses in pectic substances occur when either variety is processed by the ACB process. In reference to the particular "cold break" process used in this work, it should be pointed out that the rate of destruction of pectic substances depends upon the amount of DP and PE present as well as the temperature and time at which the enzymes are acting because the results indicate that there are still some alcohol insoluble pectic substances from the ACB process products.



Changes in consistency accompanying evaporation. The relationship between total solids content and consistency in the various samples of purees and pastes is shown on semi-log scales in Figure 2. As evaporation proceeds, the Bostwick readings decrease, indicating increasing consistency. Pastes and purees made from Pearson by HB process are markedly inferior in consistency to those from San Marzano. In fact, the latter at 20% solids has the same Bostwick reading that Pearson does at 30% solids. Furthermore, the sample made from 75% Pearson and 25% San Marzano gives a Bostwick reading approaching that of San Marzano alone. At least part of the superior consistency of San Marzano paste is due to its greater pectin content as shown in Figure 1.

The fact that concentrates made by the ACB process give consistencies inferior to HB concentrates from the same variety is shown in Figure 2. This may be explained by the loss of pectin due to pectic enzyme activity during the cold break processing.

Figure 2 shows the failure of the Bostwick to distinguish ACB paste from the HB paste at very high solids levels within either variety. This is better illustrated by data presented in Table 1 which compares the Bostwick readings of pastes with 25% total solids to the Stormer readings of these same pastes which were diluted to 10% soluble solids. On the common dilution basis, the samples from the ACB process give Stormer consistencies greatly inferior to those from HB. This points out the necessity of diluting to a common solids level for adequate

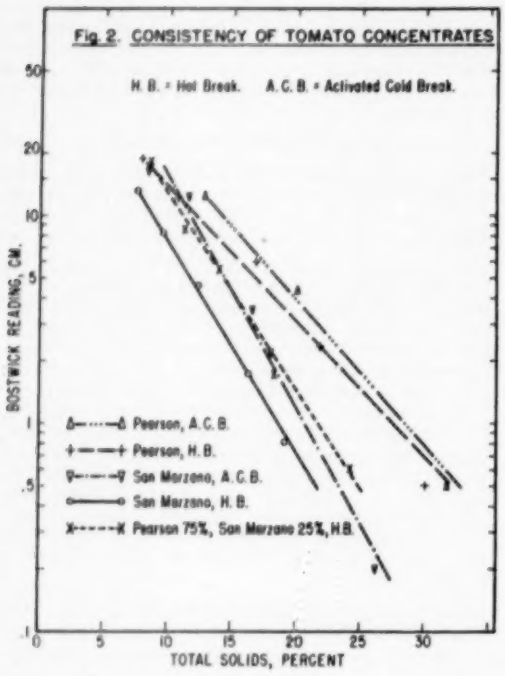


Fig. 2. CONSISTENCY OF TOMATO CONCENTRATES
H. B. = Hot Break. A. C. B. = Activated Cold Break.
BOSTWICK READING, CM.
TOTAL SOLIDS, PERCENT
Δ----Δ Pearson, A.C.B.
+——+ Pearson, H.B.
∇----∇ San Marzano, A.C.B.
o——o San Marzano, H.B.
X----X Pearson 75%, San Marzano 25%, H.B.

consistency comparison. Since high solids pastes are diluted when they are used commercially, the comparison of pastes on this basis has practical value.

Role of non-pectic alcohol-insoluble solids (AIS). Pectin has been demonstrated to be an important contributor to consistency. Besides pectin other constituents in the AIS may also be effective. This is shown by the Stormer values in Table 1 and the Bostwick curves in Figure 2. Here paste made from San Marzano by the ACB process with a pectin content of 1.53% (dry basis) has thicker consistency than that from Pearson by the HB process with 3.48% pectin. If pectin were the only constituent contributing to varietal differences in consistency, the reverse should be true. A comparison of the AIS in Table 1 suggests the possible role of the non-pectic constituents of the AIS in determining consistency. High non-pectic AIS being associated with high consistency.

The ACB process not only causes a decrease in pectin but also in non-pectic AIC content. The decrease is found to be 1.8% for Pearson and 2.5% for San Marzano. These observations are in agreement with the evidence presented by McColloch *et al. (13)* and by Williams and Bevenue *(20)*.

Effect of homogenization on consistency. The importance of particle size on the consistency of macerated tomato products has been discussed by Kertesz and Loconti *(6)* and Kimball and Kertesz *(8)*. However, no information is available on the effect of homogenization on the consistency of macerated tomato products. We have investigated the consistency of paste and puree from Pearson tomatoes, obtained by the HB process, in contrast to the same sample after homogenization. A laboratory homogenizer was used to homogenize the various samples. This was done at room temperature of 25 ± 1° C. The results are shown in Figure 3. It is obvious that the homogenized samples give better consistency than those without homogenization, both being at the same total solids content. For instance, the homogenized sample gave a Bostwick reading of 0.4 cm. at 25° C. at 26% total solids, whereas the sample with no homogenization has a value of 1.1 cm. In fact, the increase in consistency is equivalent to that obtained from a 25% San Marzano and 75% Pearson mixture. Similar trends were found when consistency was measured with the plate consistometer and the Stormer viscosimeter. The increase in consistency after homogenization might be caused by the decrease in size, change in shape, and increase in total surface area of the suspended particles. Thus the qualitative and quantitative interrelationships of the suspended particles, as changed by homogenization, can also cause changes in consistency.

Evaluation of consistency of commercial tomato paste. Seven commercial tomato pastes were compared for consistency by various methods. The solids content of these samples varied from 24.55 to 48.75%. Since the Stormer viscosimeter could not function on high-solids pastes, diluted samples at 10° Brix soluble solids content were used. The results are presented in Table 2. When the pectin contents (dry-weight basis) of these pastes were compared with the Stormer readings, obtained from the

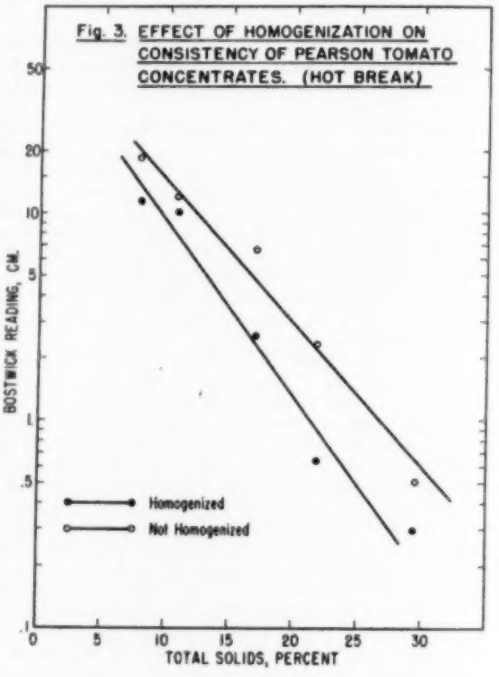


Fig. 3. EFFECT OF HOMOGENIZATION ON CONSISTENCY OF PEARSON TOMATO CONCENTRATES. (HOT BREAK)
BOSTWICK READING, CM.
TOTAL SOLIDS, PERCENT
Homogenized
Not Homogenized

TABLE 1
Comparison of tomato pastes by Bostwick and Stormer consistometers

Sample	Process	Bostwick consistometer readings of samples at 25% total solids cm.	Stormer viscosimeter readings of samples diluted to 10° Brix soluble solids sec.[1]	Alcohol insoluble solids % (dry basis)	Total pectic substances % (dry basis)
Pearson	hot break	1.5	31.2	12.6 ± .5[2]	3.48 ± .13
Pearson	cold break	1.8	9.0	8.5 ± .4	1.20 ± .10
San Marzano	hot break	0.2	388.8	17.5 ± .2	4.92 ± .10
San Marzano	cold break	0.1	74.0	11.6 ± .5	1.53 ± .03
75% Pearson 25% San Marzano	hot break	0.5	70.3	.....	.....

[1] Reading for distilled water at 28° C. was 4.0 seconds.
[2] Standard error of the mean.

diluted samples at 10° Brix soluble solids, there was a coefficient of correlation of 0.877, significant at the 1% level. A similar correlation ($r = .808$, significant at the 5% level) was found in the case of diluted serum viscosity. No significant correlation was found when total solids were compared with the Stormer readings ($r = .565$). Sample 7, which was made by the CB process from Pearson tomatoes, gave poorer Stormer and relative viscosity readings than any of the other samples. Samples 6 and 7 have the highest undiluted consistency because of their higher solids content, but they have a poorer consistency when compared with other samples of the same soluble solids content.

SIGNIFICANCE OF RESULTS

The number of variables contributing to tomato paste consistency which have been encountered in this work illustrate why there is some controversy about the subject in the paste industry. Although the HB and ACB methods used in this study may differ from common industrial procedures, they do, however, produce extreme cases which illustrate a principle. With the pastes of 36 and 46% solids now being produced, it becomes apparent that comparisons of quality as far as consistency is concerned can most easily be made on the same solids basis. Even at the same solids content, consistencies of different paste samples may vary because of (a) the quality and quantity of the pectic substances, (b) other unknown but important constituents of the alcohol-insoluble solids, and (c) the size and shape of the suspended particles. The pectic substances and other AIS fractions may differ in quality and quantity because of (a) variety, (b) enzyme degradation during processing, and (c) degradation during heating.

Therefore the processors should consider the proper selection of tomato varieties or the mixture of certain varieties, the extent of pectic enzyme inactivation during maceration, pectin changes during processing, and size distribution of the suspended particles in order to ensure a product of desirable consistency.

SUMMARY

Pearson and San Marzano tomatoes were grown and processed into purees and pastes of different solids contents. The pectin and total solids contents of these samples were correlated with consistency. Results indicate San Marzano has a higher pectin and alcohol-insoluble solids content and produces pastes of better consistency than Pearson. Replacement of 25% of the Pearson by San Marzano gave pastes of much more desirable consistency. Pearson gave paste of commercially acceptable consistency as long as there was efficient and rapid head inactivation of the pectic enzymes.

The differences in consistency between purees and pastes made by the hot break and activated cold break processes are presented. The use of the hot break process is important to obtain puree of better consistency. Homogenization of tomato paste caused improvement in consistency probably because of the change in size and shape and increase in the number of suspended colloidal particles which have a higher capacity for holding water. There was evidence that consistency, in San Marzano tomatoes particularly, is affected by constituents present in the alcohol-insoluble solids other than pectin. Non-pectin alcohol-insoluble solids were shown to undergo degradation during the activated cold break process along with the degradation of pectic substances.

A number of commercial samples of tomato pastes were evaluated for their consistency, total solids, and pectin content. Bostwick and Plate consistometers gave only apparent consistency and did not distinguish between pastes of 46% solids prepared by the hot break and cold break processes. The Stormer viscosimeter readings of the diluted paste samples at 10° Brix soluble solids had a good correlation with the pectin content on a dry-weight basis (coefficient of correlation = .877). With samples diluted to 10° Brix soluble solids, the Stormer may be used to measure consistency of pastes with different solids content, and those of different pectin content.

Acknowledgment

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LITERATURE CITED

1. Blair, G. W. S. *Foodstuffs, Their Plasticity, Fluidity, and Consistency.* 1953, Interscience Publishers, Inc., New York.
2. Gould, W. A. Consistency in processed foods. *Food Packer,* **34** (4), 42, 58-60 (1935).
3. Hamson, A. R. Factors which condition firmness in tomatoes. *Food Research,* **17**, 370-379 (1952).
4. Kassab, M. A. Observations on the pectin content of California tomatoes. *Fruit Products J.,* **11**, 69-70 (1931).
5. Kertesz, Z. I. *The Pectic Substances.* 1951, Interscience Publishers, Inc., New York, N. Y.
6. Kertesz, Z. I., and Loconti, J. D. Factors determining the consistency of commercial canned tomato juice. N. Y. Agr. Expt. Sta., Geneva, N. Y., *Tech. Bull. 272* (1944).
7. Kertesz, Z. I., and McColloch, R. J. The pectic substances of mature John Baer tomatoes. N. Y. State Agr. Expt. Sta. *Bull. 745* (1950).
8. Kimball, L. B., and Kertesz, Z. I. Practical determination of size distribution of suspended particles in macerated tomato products. *Food Technol.,* **6**, 68-71 (1952).

TABLE 2

Relationship of pectin and solids content to consistency in commercial tomato pastes.

Sample	Total solids %	Total pectic substances %		Alcohol insoluble solids % wet basis	Bostwick reading cm.	Plate consistometer reading	Rate of filtration of diluted sample ml./30 min.	Relative viscosity of diluted serum by Ostwald viscosimeter	Stormer at 28° C. in sec. (diluted to 10° Brix)[1]
		wet basis	dry basis						
Ordinary Tomato Paste									
1	24.55	1.065	3.95	3.83	0.4	2.6	6.8	1.600	46.0
2	26.75	0.914	3.42	3.68	0.5	2.9	8.3	1.478	22.0
3	27.56	0.914	3.32	4.22	0.3	2.6	10.8	1.440	17.0
4	26.96	0.644	2.38	3.09	1.3	3.2	10.8	1.387	9.6
5	26.19	0.581	2.22	3.13	0.8	3.1	18.5	1.506	8.4
High Solids Paste									
6	46.80	1.012	2.16	6.17	0.0	1.6	9.0	1.385	6.0
7	48.75	0.668	1.42	7.40	0.0	1.2	11.3	1.312	5.2

[1] Reading for distilled water at 28° C. was 4.0 seconds.

9. Luh, B. S., Leonard, S. J., and Dempsey, W. H. Pectic substances of Pearson and San Marzano tomatoes. *Food Research*, **19**, 146-153 (1954).

10. McColloch, R. J. Determination of pectic substances and pectic enzymes in citrus and tomato products. U. S. Dept. Agr., Fruits and Vegetable Chemistry Laboratory, Pasadena, Calif., *AIC-337* (1952).

11. McColloch, R. J., Keller, G. J., and Beavens, E. A. Factors influencing the quality of tomato products. I. Surface-localized pectic enzymes inactivated by blanching. *Food Technol.*, **3**, 94-96 (1949).

12. McColloch, R. J., and Kertesz, Z. I. Recent developments of practical significance in the field of pectic enzymes. *Food Technol.*, **3**, p. 94-96 (1949).

13. McColloch, R. J., Nielsen, B. W., and Beavens, E. A. Factors influencing the quality of tomato paste. II. Pectic changes during processing. *Food Technol.*, **4**, 339-343 (1950).

14. McCready, R. M., and McComb, E. A. Extraction and determination of total pectic materials in fruits. *Anal. Chem.*, **24**, 1986-1988 (1952).

15. Saywell, L. C., and Cruess, W. V. Composition of canning tomatoes. Calif. Agr. Expt. Sta. *Bull. 545* (1932).

16. Smith, H. R. The consistency of tomato catsup. *Canning Trade*, **54**, 14 (1931).

17. Underwood, J. C. Factors influencing quality of tomato paste. I. Chemical composition of California commercial tomato paste. *Food Research*, **15**, 366-372 (1950).

18. Underwood, J. C., and Keller, G. J. A method for measuring the consistency of tomato paste. *Fruit Prod. J.*, **28**, 103 (1948).

19. U. S. Standards for Grades of Tomato Catsup (Effective April 15, 1941). Production and Marketing Administration. U. S. Dept. of Agr.

20. Williams, K. T., and Bevenue, A. Some carbohydrate components of tomato. *J. Agr. Food Chem.*, **2**, 472-473 (1954).

Consumer Evaluation of the Flavor of Angel Cakes Prepared from Yeast-Fermented and Enzyme-Treated Dried Albumen[a,b]

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A total of 900 consumers were used in an evaluation of angel cakes made with glucose-free dried albumen. Angel cakes made with frozen egg white were used as controls. Data are presented on triangle taste test comparisons made between control angel cakes and cakes prepared from: 1) yeast-fermented, pan dried albumen; 2) enzyme-treated, pan dried albumen; 3) yeast-fermented, spray dried albumen; and 4) enzyme-treated, spray dried albumen. Also angel cakes prepared from yeast-fermented, pan dried albumen were compared with those made from yeast-fermented, spray dried albumen. Another test was made to compare the flavor of cakes prepared from yeast-fermented, pan dried albumen with that of cakes prepared from frozen egg white and in this test all of these cakes had vanilla in the formula.

High quality dried albumen is available on the present day market. Many of the improvements in this dried egg white have resulted from extensive research on the factors that affect stability, color, purity and solubility of the product. However, in the final analysis, consumer acceptance of products prepared with dried albumen depends, to a large extent, upon the flavor. Flavor is not easily measured; hence a dearth of information that would enable one to answer such questions as "Can the consumer distinguish between the flavor of angel cakes made with fresh or with dried egg whites?" or "To what extent does the agent used in the removal of the glucose or the method used for drying affect the flavor and the acceptance of angel cakes made with dried albumen?"

For a number of years considerable research has been done at Iowa State College on problems related to the removal of glucose from albumen prior to drying *(1, 2, 3, 4, 7, 8)*. Three methods that have been studied for the removal of glucose from albumen included bacterial or yeast fermentation and enzyme treatment. In tests wherein the foaming properties and flavor of the glucose-free dried albumen have been investigated *(3, 4)*, trained taste panels were used to evaluate differences in the quality of angel cakes made with different samples of glucose-free dried albumen. Since the flavor that dried eggs might impart to food products was of particular interest, vanilla flavoring was not used in any of the angel cakes given to the laboratory taste panel. Results of these comparisons indicated that some individuals could identify an "after-taste" in angel cakes made with yeast-fermented dried albumen, but that panel members could not correctly identify angel cakes made from enzyme-treated dried albumen when compared to control cakes *(3, 4)*. In the tests reported previously, relatively small groups were used and since the cakes did not contain vanilla, they were atypical to this extent. Thus it seemed desirable to enlarge the population to include possible consumers of angel cake mixes and, also, to include one test in which vanilla was used in all cakes.

The present study was directed toward an estimation of consumer preference in which 900 individuals were randomly selected for the panels used to appraise the flavor of angel cakes made with various samples of glucose-free dried egg white. Information was obtained on the consumer's ability to identify angel cakes that were made with glucose-free dried albumen and without vanilla flavoring. In addition, the effect on flavor of adding vanilla to the cakes made with yeast-fermented, pan dried albumen was evaluated.

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[b] Presented at the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 23, 1953.

EXPERIMENTAL PROCEDURE

The tests were conducted for 2 days in May, 1952 and 1953. Angel cakes prepared from frozen egg white and from different samples of glucose-free dried albumen were submitted to large consumer panels for evaluation.

The samples of angel cakes compared are listed in the left hand column of Table 1.

TABLE 1
Summary of results on triangle tests made with angel cakes

Egg samples compared in angel cakes	Number of participants		
	Correct	Incorrect	Total
1952	*No.*	*No.*	*No.*
Test No.			
I. Yeast-fermented, pan dried [1] vs. frozen albumen	126**	116	242
II. Enzyme-treated, pan dried [1] vs. frozen albumen	107**	152	259
Total	233	268	501
1953			
III. Yeast-fermented, spray dried [2] vs. frozen albumen	42*	58	100
IV. Enzyme-treated, spray dried [2] vs. frozen albumen	58**	42	100
V. Yeast-fermented, pan dried [1] vs. frozen albumen (vanilla) [3]	39	61	100
VI. Yeast-fermented, pan dried [1] vs. yeast-fermented, spray dried albumen [2]	41	59	100
Total	180	220	400

* Significant at 5% level.
** Significant at 1% level.
[1] Dried egg samples prepared in the Iowa State College laboratory.
[2] Dried egg samples obtained from a commercial source.
[3] Vanilla added to all cakes in this test.

Frozen and pan dried albumens were prepared from eggs 3 days old obtained from the Iowa State College Poultry Farm. For the angel cakes made in 1952, sufficient egg white for 250 small angel cakes was blended, pooled and then divided into 3 parts. One-third of the albumen was enzyme-treated and pan dried; one-third was yeast-fermented and pan dried; the remainder was frozen at —30° F. (—34.4° C.). Procedures used for glucose removal (yeast fermentation and enzyme treatment) and drying have been described previously *(3, 4)*. In 1953 yeast was the only agent used by the Iowa State College laboratory to remove glucose from the pan dried albumen. The spray dried albumen, both yeast-fermented and enzyme-treated, was obtained commercially.

The formula and method adopted for the angel cakes was similar to that used previously *(3, 4)* with these exceptions: (a) the formula given in *(3)* was increased six and one-half times and a Hobart (model C-10) speed 3, was used for beating the meringue and (b) 110 g. of angel cake batter were weighed into each of 8 small baking pans and all of the cakes were baked simultaneously in the same Despatch Rotary Oven (model-150-R). Since it was impossible to make all the cakes on the day preceding the tests, they were made during the previous week and frozen. Preliminary experiments had indicated that angel cakes frozen and held in frozen storage a short period of time could not be distinguished from fresh angel cakes.

Consumer panel. An Open House planned each year in May by the faculty and students of Iowa State College for high school students and parents attracts large numbers of people to the campus. The sample of consumers used for the panels was drawn from this urban and rural population of males and females ranging in age from 12 to 70 years. Their exact age and sex distribution can be seen in Table 2.

The test was administered by members of the Home Economics Research and Statistics Departments. In the "triangle" or odd sample method used for evaluation of angel cakes there are 6 possible orders in which samples may be presented: AAB, ABB, BAA, BBA, ABA, BAB (A = cake made with frozen eggs, B = cake containing dried eggs). All the possible combinations were used in the test. Since 2 of the samples are identical and 1 is different, the probability of a taster guessing the correct answer is one-third.

Each consumer took only one test; he was given a paper containing 3 slices of angel cake with code numbers below each slice (2 slices were from the same angel cake, the third slice was from another cake). Explanation of the test was given to 3 members of the panel at one time. Precautions were taken to secure independent selections. No 3 people at a table had the same test or code numbers. The score card contained 2 questions: "Which samples are identical?" and "Which sample(s) do you prefer?" If an individual answered the first question correctly, then his preference was valid.

RESULTS AND DISCUSSION

The effects of method of glucose removal or method of drying on the flavor of angel cakes made with dried egg white were investigated using large consumer panels. Comparisons using the triangle test method were made between angel cakes that contained frozen egg white and cakes made with various samples of glucose-free dried albumen (Table 1). Also, individuals were asked which sample they preferred. Answers to this question were tabulated only when the individual correctly selected the identical samples in the triangle test. The data are summarized in Table 1. The minimum number of correct answers required for significant differentiation computed by the normal approximation with Yates' correction for a one-tailed test *(9)* are:

Number of tasters	Level of significance		
	P = 0.01	P = 0.05	P = 0.10
100	45	42	40
242	98	93	91
259	104	99	97

Effect of glucose removal on angel cake flavor. The data given in Table 1, for tests I and II conducted in 1952, indicated that the flavor of angel cakes made with either yeast-fermented or enzyme-treated pan dried albumen was significantly different at the 1% level from the flavor of angel cakes made with frozen egg white. However, of the 233 consumers who were correct in their identification of the cake samples, 51% correctly identified the yeast-fermented dried egg sample as compared with only 39% for the enzyme-treated dried egg samples. Previous results *(4)* obtained with laboratory taste panels indicated that the judges used were not able to distinguish between the flavor of cakes made with frozen egg white and that of cakes made with enzyme-treated, pan dried albumen, but they were able to identify cakes made with yeast-fermented dried eggs when the cakes did not contain vanilla flavoring.

In tests III and IV (Table 1) made in 1953 with commercial spray dried egg powders, 100 of the total 200 consumers were unable to distinguish between cakes made with dried eggs and those made with frozen egg white. If the results of the tests given in 1952 and 1953 are added, one finds that 368 of 701 consumers tested or 52.5% could not identify cakes made with dried egg white regardless of method of glucose removal and even though vanilla was not used in the formula.

On the other hand, an examination of the number of participants who were correct in tests I, II, III, and IV (Table 1) reveals that in test IV more individuals

TABLE 2
Distribution of the results of triangle tests on the basis of age and sex of consumers

Test No.	Egg samples compared in angel cakes	Number of consumers	Male			Female		
			12-19 years	20-70 years	Total	12-19 years	20-70 years	Total
I	Yeast, pan dried vs. frozen, 1952	correct	24	17	41	35	50	85
		incorrect	27	23	50	26	40	66
					91			151
II	Enzyme, pan dried vs. frozen, 1952	correct	19	27	46	14	47	61
		incorrect	29	45	74	26	52	78
					120			139
III	Yeast, spray dried vs. frozen, 1953	correct	8	12	20	10	12	22
		incorrect	18	13	31	14	13	27
					51			49
IV	Enzyme, spray dried vs. frozen, 1953	correct	14	9	23	11	24	35
		incorrect	15	3	18	13	11	24
					41			59

identified the enzyme-treated, spray dried samples than the yeast-fermented, spray dried samples in test III. These results are the exact opposite of those obtained in tests I and II in which more individuals could identify cakes made with yeast-fermented, pan dried albumen.

A comparison of the data obtained in test I and test V (Table 1) reveals the interesting effect of vanilla in masking the foreign flavor found in angel cakes made with yeast-fermented, pan dried albumen. When vanilla was used in all angel cakes made with either the dried or frozen egg white, there was not a significant number of consumers who could select the cakes made with yeast-fermented, pan dried albumen. In other words the 39 individuals who identified the cakes correctly might have done so by chance alone. Therefore, from a practical viewpoint, when a typical angel cake recipe was used, the dried albumen was found to be as satisfactory as the frozen egg white for making angel cakes.

Effect of method of drying on angel cake flavor. Some commercial producers of spray dried egg powder were of the opinion that spray drying was more effective than pan drying in removing the "yeasty odor" from yeast-fermented albumen. Also, in a study of the removal of glucose from *whole egg* melange by yeast fermentation, Kline and Sonoda *(5)* concluded from their results that plant-scale operations of pasteurization and spray drying removed the yeast flavor and odor much more effectively than did the laboratory lyophilization process. However, under the conditions employed in the test reported here in which the 2 different samples of yeast-fermented dried eggs were compared in angel cakes, the consumer evaluation did not reveal that the laboratory process of glucose removal with pan drying was more effective in the removal of residual "yeastiness" (test VI) than was the commercial operation with spray drying.

Angel cakes made from the enzyme-treated samples which had been prepared and dried in the laboratory were not compared in the same test with cakes made with the commercial samples of enzyme-treated, spray dried egg whites. However, in tests II and IV, each of these dried samples in cakes was compared with the frozen control cakes. Only 39% of the consumers were correct in their selection of the cakes made with enzyme-treated, pan dried albumen, whereas, 58% of the consumers were able to identify the enzyme-treated, spray dried sample. It should be pointed out that the differences obtained in these tests might not be due to method of drying, but rather to differences that might exist between laboratory and commercial methods employed in the removal of glucose even when the agent used to remove the glucose is similar in both processes.

Analysis of data on basis of age and sex of consumers. Information was obtained on the age and sex of all individuals participating in order to determine the correlation between these characteristics and the ability to correctly identify the samples of angel cake. For example, many individuals hold the opinion that young people are more acute in the detection of odor and taste than older people. Table 2 was prepared to study the interactions of percentages correct with age and sex (excluding the data for tests V and VI in 1953). The three factor interaction was tested for significance for each of the tests and none even approached significance at the 5% level. Since the 3-factor interactions were negligible, the data were combined for the 2 age groups to study the interaction of sex with percentage correct. In none of the 4 tests was this interaction significant. Then the data for the 2 sexes were combined to study the interaction of age with percentage correct. Also, the age group 20-70 years was divided into 2 groups: 20-29 and 30-70 years. This interaction was not significant for tests I and III, but was significant for test IV and approached significance, at the 5% level for test II. These results indicate a higher percentage of the older people could correctly detect the difference between the flavor of angel cakes made with enzyme-treated dried albumen and those made with frozen egg white.

Consumer preferences. The data on consumer preferences (Figure 1) clearly indicate that in each test more people preferred the angel cakes made with frozen egg whites rather than any of the cakes made with dried albumen. Attention is called to the fact that the two tests with the highest percentage of consumers who preferred frozen egg white, namely 75% and 69%, are the same tests (Table 1; tests I, IV) in which the highest percentage of consumers correctly identified the odd sample. Also, the addition of vanilla to angel cakes made with yeast-fermented, pan dried albumen raised the preference for these cakes from 25% to 45%. The

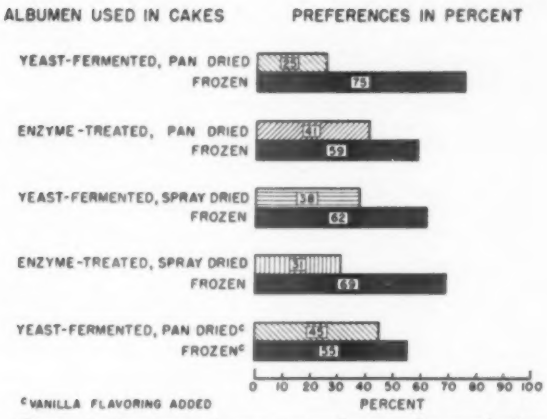

Figure 1. Summary of consumer preferences for angel cakes made with frozen egg white or with dried egg white.

use of vanilla in the angel cakes made with yeast-fermented, pan dried egg white changed the preference for these cakes from the least to the most preferred of all the dried egg samples tested.

Some practical applications. The results obtained with consumer panels comparing the flavor of cakes made with either yeast-fermented or enzyme-treated dried albumen and frozen egg white have clearly shown that the agent used in the removal of glucose from egg white induces significant changes in the flavor. If vanilla was not included in the cakes made from dried albumen, a significant number of consumers were correct in their identification of these samples and from 59% to 75% of the consumers preferred cakes made from frozen egg white. But if vanilla was used in the angel cakes, a relatively small number could distinguish the flavor of the dried egg sample and the preference for cakes made with frozen egg white dropped to 45%. From a practical standpoint, commercial angel cake mixes might be more certain of favorable acceptance if vanilla were included at the time of packaging, rather than risk having the housewife forget to add it.

SUMMARY

In 1952, a consumer panel of 501 individuals ranging in age from 12 to 70 years was given triangle taste tests to evaluate the flavor of angel cakes prepared from various samples of dried egg white. The flavor of angel cakes containing enzyme-treated, pan dried albumen was compared to that of cakes made with frozen egg whites by 259 consumers. A highly significant number, 107, of these individuals correctly identified cakes made with dried egg white. Of these 107 consumers, 59% preferred angel cakes made with the frozen egg white.

Of the 242 consumers who compared the flavor of angel cakes made with yeast-fermented, pan dried albumen with those prepared from frozen egg whites, a highly significant number, 126, were able to select the samples made with dried egg white. Of these 126 consumers, 75% preferred the cakes made with frozen egg white. In 1953, a similar test was given to 100 consumers except vanilla was added to all the cakes. In this test, only 39 individuals could correctly identify the samples prepared from the yeast-fermented, pan dried albumen with vanilla added to the cake. One might expect this number of individuals to be correct by merely guessing, hence, the flavor differences between the 2 samples of cake were not significant. This would indicate that vanilla can be used to successfully mask the foreign flavor found in angel cakes prepared from yeast-fermented, pan dried albumen.

In 1953, 100 consumers compared angel cakes prepared from commercial samples of yeast-fermented, spray dried albumen with those made from frozen egg white. Of the 100 consumers, 42 were able to select the angel cakes containing the dried egg albumen and 62% of these preferred the angel cakes made with frozen egg white. In a second test, another 100 consumers compared the commercially prepared, enzyme-treated, spray dried albumen in angel cakes with frozen egg white in angel cakes. Of these 100 consumers, 58 correctly identified the angel cakes containing the dried egg sample and 69% of these preferred the angel cakes made with frozen egg white.

Hence, when vanilla is omitted from the formula, there is a significant difference in the flavor of angel cakes prepared from either laboratory samples of pan dried albumen or commercial samples of spray dried albumen regardless of the method of glucose removal.

Another group of 100 consumers were not successful in identifying the flavor of cakes made with yeast-fermented, pan dried albumen or those made with yeast-fermented, spray dried albumen when these 2 samples were compared in the same test. If one assumed that yeast fermentation for the removal of glucose is similar in the laboratory and in the commercial operation, then one might conclude that the method of drying does not significantly alter the flavor of the resulting dried albumen.

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LITERATURE CITED

1. Ayres, J. C., and Stewart, G. F. Removal of sugar from raw egg white by yeast before drying. *Food Technol.*, **1**, 519 (1947).
2. Bollenback, C. Removal of glucose from egg albumen by a controlled fermentation. (Unpublished Ph.D. Thesis, 1949, Ames, Iowa. Iowa State College Library.)
3. Carlin, A. F., and Ayres, J. C. Storage studies on yeast-fermented dried egg white. *Food Technol.*, **5**, 172 (1951).
4. Carlin, A. F., and Ayres, J. C. Effect of the removal of glucose by enzyme treatment on the whipping properties of dried albumen. *Food Technol.*, **7**, 268 (1953).
5. Kline, L., and Sonoda, T. T. Role of glucose in the storage deterioration of whole egg powder. I. Removal of glucose from whole egg melange by yeast fermentation before drying. *Food Technol.*, **5**, 90 (1951).
6. Slosberg, H. M., Hanson, H. L., Stewart, G. F., and Lowe, B. Factors influencing the effects of heat treatment on the leavening power of egg white. *Poultry Sci.*, **27**, 294 (1948).
7. Stewart, G. F., and Kline, R. W. Dried-egg albumen. I. Solubility and color denaturation. *Proc. Inst. Food Technol.*, p. 48 (1941).
8. Stewart, G. F., and Kline, R. W. Factors influencing rate of deterioration in dried albumen. *Ind. Eng. Chem.*, **40**, 916 (1948).
9. Yates, F. Contingency tables involving small numbers and the chi-square test. *J. Roy Stat. Soc.* Suppl., **1**, 217 (1934).

APPERT - *Charles, Francois or Nicolas?*

A Biographical Note Documenting a Famous Name

It is perhaps inevitable in perpetuating the name of an illustrious personage, that a question will arise as to the exact Christian name by which such a person was known among his contemporaries. A doubt can logically be raised by impartial scholars when there is a dearth of reliable records.

In establishing the Nicholas Appert Medal Award, the Chicago Section of the Institute of Food Technologists assumed on the basis of available references that it was honoring the memory of a French confectioner accredited with the epochal discovery of preserving foods by sterilizing them in a sealed container. There is no record that outlines what evidences the group responsible for its creation may have studied in concluding that the Christian name of this patron saint of our modern canning industry was — in truth — Nicholas, as the coveted medal itself has emblazoned upon its obverse side. It is assumed that they were largely influenced by the writings of the late Dr. Bitting. While these gentlemen can be excused for anglicizing the French "Nicolas" to the English "Nicholas," they would be disturbed (as indeed would all the Medalists themselves) to learn, at this late date, that they might be using the wrong Christian name of the personage whose memory it was—and is—desired to so venerate.

To add to previous confusions of fact, it was recently discovered that one of the French references, enjoying some aura of authenticity, accredited the discovery to a *Francois* Appert. Still other references mention a *Charles* or a *Claude* Appert. This state of uncertainty led to an appeal to the French Government by the writer, as historian of the Chicago Section of the Institute of Food Technologists, to help establish the facts. In this connection, the office of the French Consulate General at Chicago was most helpful; their inquiries led to the Archives of the Department of the Marne where it was revealed that the chief archivist, M. Rene Gandilhon, had made an exhaustive study of the matter at the request of the municipality of Chalons-on-the-Marne. In presenting his report and supporting evidence, Monsieur Gandilhon read the statement that will follow.

It should be mentioned in passing that officials of Chalons-on-the-Marne gave the assignment to M. Gandilhon in order that they might be assured that the proper name, particularly the Christian name of its native son, would be used to designate one of its streets about to be dedicated to his memory. Prior to the report of M. Gandilhon, the name Claude Appert had been proposed.

In appreciation of this service to the memory of Nicolas Appert, the Chicago Section presented to M. Gandilhon a scroll and an Appert Medal through the person of the French Consul General at Los Angeles on June 28, 1954, upon the event of the presentation of the 1954 Nicholas Appert Medal to Dr. Charles N. Frey. M. Gandilhon's statement, in translation, follows:

Nicolas Appert—Creator of the Food Preservation Industry

RENÉ GANDILHON
Archivist, Archives of the Department of the Marne, Chalons-sur-Marne

In a scholarly dissertation on "the glorious past of Châlons" *(1)*, our fellow citizen, M. Vendel, commented some years ago, and not without humor, that the village of Châlons seemed to have forgotten its illustrious son by failing to render even the simple homage of giving his name to a street or a public place. Perhaps Châlons has not sought out the names of artists or inventors born within its limits! Actually, had it done so, it probably would have had negative results with regard to the former. However, permit me to offer, by contrast, some evidence that the latter would have been fruitful—for example, in revealing the name of Nicolas Appert.

Lest many of this region do not know this personage, or his patronym, or even have any information whatsoever concerning him or his family, I shall take this occasion to advise you that this native son of Châlons is deserving of the gratitude of his country and of all humanity. Nicolas Appert was the creator of the food preservation industry. Thanks to his ingenuity, and antedating the great Pasteur, the sterilization of food materials and their preservation in wide-mouthed glass bottles, and in canisters of white iron, was made possible. His discovery permitted "the consumption of fruits or vegetables in other seasons, long after their harvest, in foreign lands or on board ships."

IN SEARCH OF A NAME, PLACE, AND DATE

The investigations that I have made concerning this individual have had for their objective, the answers to two questions: what was the actual Christian name of this inventor?; where and when was he born? Even the fine *Dictionary of French Biography* that has given him conspicuous notice has been hesitant in answering these questions. Rather, it leaves to choice the Christian names of Charles, Francois, or Nicolas and only approximately fixes the date of his birth at around 1750 in one of the Châlons of Champagne *(2)*—all of this based upon information gleaned from his death certificate.

After extensive investigations, I can be precise on various points. I can assure you that Nicolas Appert was born at Châlons-on-the-Marne on the date of 17 November 1749, in the parish of St. Jean, at the tavern of The White Horse *(3)*. He was born of the marriage of Claude Appert, innkeeper, and Marie-Nicole Huet who were united in wedlock on the date of 9 November 1739 in the church of St. Jean *(4)*. Three brothers, Louis Gervais *(5)*, Jean-Baptiste *(6)*, and Claude-Francois *(7)* were born to them and there were four other infants who died at an early age *(8)*. Their father was innkeeper and proprietor, at least from 1740 to 1749, of The White Horse, located on Basse-Sainte—Jean Street, then called Jean-Jacques-Rousseau Street *(9)*. Such personages as Augustin Lamarquant, comptroller general of the house of the Duke of Penthievre *(10)*, Louis Mathe of Gauville, Lord of Coolus *(11)* stood as godfathers for these children at their baptism. In his district, the father also played certain rôles of local prominence—for example, during 1747-1748, he signed as a witness all the deeds of burial of Dutch soldier prisoners who died in captivity in the

village of Châlons *(12)*. After 1750, he purchased the hotel of the Royal Palace, adjoining the St. Lazare Hospital, St. Jacques Street—later Leon Bourgeois Street—of which there remains no trace *(13)*, all having been destroyed in 1940. This hotel, I would have you realize, was a most important one for its era and comprised twenty rooms named somewhat curiously for certain cities: for example, Chamber of Turin, of Londres, of Mannheim, of Constantinople. Several rooms had rather sumptuous decorations including spans of high gloss tapestry. The cellar was unusually well provided with different vintages of sparkling wines—and a special wine of the color of oat straw. It was at that time a hotel and not an inn, and it was here that Nicolas Appert served his apprenticeship in his profession.

Before his installation as hotelier at Rethel *(15)*, Nicolas began to follow in his father's footsteps. After learning the rudiments of his profession at Châlons, he founded a brewery, along with his brothers Louis and Claude, for which he tried to obtain patent to the title "Royal Brewery" *(16)*. He then went abroad and in 1772-1773 served as a cook for the duke of Deux-Ponts, Christian IV, then as cook officer at the home of Princess Forbach. Following the death of his father, he was given title to the name Hotel of the Royal Palace by virtue of the patent act. It was during this time of his career that he became widely recognized as "the confectioner of Paris located at the Street of Lombards." He became deeply interested in the preservation of foods of various sorts including vegetables and meats. After appreciable experimentation, he concluded that heating foods in a closed vase could definitely stop fermentation as well as assure an indefinite preservation of various substances. He obtained from the Ministry of the Navy, the authorization to ship on board vessels the products of his manufacture and from these experiences derived the certificates of commendation *(17)* that attracted official notice.

Napoleon, having been informed of Appert's discovery, gave him a grant of 12,000 francs with the sole stipulation that he make public his invention. Appert then published *A Book for All the Housekeepers*, or *The Art of Preserving All Animal and Vegetable Substances for Several Years (18)*, which was translated into German and was widely distributed during its seven editions.

HIS LEGACY TO FOOD TECHNOLOGY

Nicolas Appert erected a factory at Massy (Seine-et-Oise) to exploit his process, but ruined by the invasion of 1814 and unsupported by the government in restoring his properties, he lived to see his process undergo extensive exploitation in England. He was later completely abandoned and completely ruined. When he died at Massy on the first of June 1841, there were insufficient funds to pay for his burial.

Nevertheless, it was his invention that led to the establishment of the thousands of factories widely distributed throughout the entire world that daily process literally tons of animal and vegetable produce—canned foods that can be transported, stored, and utilized remote from their sources of production. Thus has his legacy rendered an extremely great service to all mankind.

DOCUMENTARY EVIDENCES

DOCUMENT I.

Nov. 9, 1739. Châlons-sur-Marne, Parish Saint-Jean. Marriage of Claude Appert and of Marie-Nicole Huet. The year one thousand seven hundred thirty-nine, the ninth of November, after the publications of the three bans in this church (which is that of Our Lady of this village) at parish masses on the Sundays of October twenty-fifth, and first, and eighth of November; take notice of this certificate of M. Vicar of Our Lady, delivered this day and signed Jacquet: After yesterday's ceremony of the dowry, without finding opposition nor hindrance, I, the undersigned vicar of the parish administered the sacraments of marriage and gave nuptial benediction to Claude Appert, age 28 years of the parish of Our Lady, son of Jean Appert and the deceased Anne Perardel, of the parish of Saint Remy, and of Marie-Nicole Huet, of this parish, age 25 years, daughter of the deceased Francois Huet and Marie Berteault, of this parish, in the presence of Jean Appert, father of the bridegroom and Francois Appert, brother, and Francois Huet, clerk of this diocese, and of Christophe Mirbel, his uncle, and others that have signed with us.

Signed: Claude Appert, Marie-Nicolle Huet, Jean Appert, C. Mirbel, Huet, Francois Appert, Dupays, D. Lamotte, Laverne, Jean Freminet, Morlet, vicar.

(*Arch. Dep. de la Marne*, E, Châlons-sur-Marne, St. Jean, 1739).

DOCUMENT II.

Nov. 17, 1749. Châlons-sur-Marne, Parish Saint-Jean. Birth certificate of Nicolas Appert. The year of grace, one thousand seven hundred forty-nine, the seventeenth of November, I, priest, vicar of this parish, have baptized a son, born on this day of the legitimate marriage of Claude Appert, innkeeper of the White Horse, and of Marie Huet, who have imposed upon him the name Nicolas. The godfather, Mr. Nicolas Regnauld, ensign captain of the Arquebuse, the godmother, Miss Marie-Anne Meunier, both of the parish of Saint-Alpin who have signed with us. Signed: N. Regnauld, Marie-Anne Meunier, Gellé.

(*Arch. Dep. de la Marne*, E, Châlons-sur-Marne, St. Jean, 1749).

DOCUMENT III.

June 2, 1841. Massy (Seine-and-Oise). Death Certificate of Nicolas Appert. On the second of June, one thousand eight hundred and one, hour of ten of the morning, death certificate of Nicolas Appert, independent gentleman, age of four decades eleven years passed, born at Châlons (Marne), deceased here, at the eighth hour of the evening, in his home on Grand Street, legitimate son of the deceased Claude Appert and Marie Huet, his wife, widower of Elisabeth Benoist. The witnesses were M. Lecomte Charles, proprietary age of fifty years, and M. Jaumet Alexis, proprietary age of forty-four years, both neighbors of the deceased, who have signed with our mayor after reading (being sworn in) and the deceased verified by our undersigning (follows the signature).

(*Arch. mun. de Massy* reg. civil, 1841).

REFERENCES

1. Henri Vendel. *"Le beau passé de Châlons; artistes Chalonnais de jadis et de naguere."* Châlons-sur-Marne, 1928, in 8°, 32 p.
2. *Dictionnaire de Biographie Francais*, 1936, in —4° fasc. XIII, Col. 140-145. Paris.
3. See Document No. II.
4. *Arch. Dep. de la Marne*, E, Parish registers, Châlons-sur-Marne, Parish St.-Jean, 1739.
5. Born Oct. 19, 1740, at Châlons-Sur-Marne, Parish of St. Jean.
6. Born Dec. 26, 1741, at Châlons-Sur-Marne, Parish of St. Jean.
7. Born Jan. 10, 1746, at Châlons-Sur-Marne, Parish of St. Jean.
8. Augustin and Marie-Marguerite, born April 12, 1743; Marie-Marguerite born Nov. 13, 1744; Marie-Reine born April 7, 1748, at Châlons-sur-Marne, Parish of St. Jean.
9. Louis Grignon. *Topographie Historique of the Ville de Châlons-sur-Marne*. 1889, in 8°, pp. 277, Châlons-sur-Marne.
10. Godfather of Augustin Appert, born April 22, 1743.
11. Godfather of Claude-Francois Appert, born Jan. 10, 1746.
12. *Arch. Dep. de la Marne, E.* Parish registers, Châlons-sur-Marne, Parish St.-Jean 1747-1748.
13. Louis Grignon, *op. cit.*, page 310, under the revolution, the sign "Hotel of the Royal Palace" was replaced by "Hotel of the National Palace, previously Royal Palace." The commissioner of the executive directive of the municipal administration of Châlons considered it subversive and "contrary to good order" and ordered the words "previously Royal Palace" to be removed. (J. Berland. *Revolutionary names and changes of names of particular communities in the department of the Marne, in Memoire of the agriculture, commerce, science and arts society of the department of the Marne*, 2nd series, vol. XI, 1907-1908, p. 409-411.)
14. *Arch. Dep. de la Marne, B.* Report—peerage of Châlons, inventory after death, Nov. 15, 1780.
15. *Ibid.* Power of attorney given for Louis-Gervais Appert to Francois Huet, rector of Coolus, at Zutphen (Nov. 2, 1778).
16. *Arch Dep. de la Marne*, C. 483. Amiable communication from M. J. Berland, honorary archivist of the Marne.
17. *Arch. Nat.* F12, 2432. Appert file.
18. *Bibl. Nat.*, imprint, V. 30483, V. 30485; S. 22516.

July 29, 1954

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The Canning Industry Nutrition Program[a]

EDWIN J. CAMERON

WHEN the first Stephen M. Babcock Award was made in 1948 it was prefaced with an excellent summary of Dr. Babcock's career. From this, and from the tribute paid to Edwin Bret Hart earlier on this program, it is easy to sense why it has been thought proper to identify the Institute's Award for advancement of nutrition with the names of these great men. Indeed there are probably few later contributions to our knowledge of this subject that could not be shown by some series of steps to be related to their pioneer work. This would undoubtedly be as true of research on nutritive values of canned food as of any other, though I shall not undertake to trace out here the intervening steps.

Though this paper deals mainly with developments of the past twelve or so years, the canning industry's interest in nutritional science began much earlier, at about the time that vitamins began to capture the attention of the general public and not merely that of the laboratory scientists of earlier days. Not much, perhaps, was known about vitamins at that stage, but enough to suggest that a new era was beginning.

Putting this time at about 1922, we find in earlier years a considerable accumulation of information on proximate composition of many types of food, but little about canned foods. The classic compilation of Atwater and Bryant *(5)*, as revised in 1906, contained 60 pages of tables in fine print. Of these, canned food items accounted for a total of about four pages, and these items were a meager sampling of the range of canned foods as they are known today.

By the third decade of this century the evidence of existence of accessory nutritional factors and their importance was impressive enough to catch the popular imagination. It was clear that thenceforth this newer knowledge would profoundly affect dietary habits and consequently the acceptance of various classes of food. In this situation it was natural for the canning industry to wonder how it was going to fare in the coming years, and it looked to the National Canners Association for guidance.

As a first step, Kohman surveyed existing literature on the vitamins then known from the standpoint of their occurrence in foods commonly canned, and of the factors that might influence their retention in the canning process. This survey, published in 1922 as a National Canners Association Laboratory bulletin *(19)*, was revised several times in later years to incorporate the results of experimental studies.

The initial evidence assembled by Kohman was reassuring as far as it went, but it needed confirmation and extension by actual experimental studies on canned foods. Such studies were promptly launched under a cooperative arrangement with Teachers College, Columbia University. On behalf of the Association, Kohman directed the technological side of this program and at Columbia, W. H. Eddy directed the nutritional assays. This collaboration continued for 15 years and resulted in some 17 papers *(18)* on the general subject of vitamins in canned foods. As the work progressed the results were reflected also in periodic revisions of the Association's bulletin on this subject. Throughout the 15-year period the studies were pressed with admirable vigor and imagination, and did much to establish the nutritional virtues of canned foods within the framework of knowledge as it then existed, to dispel the then commonly held notion that heat processing destroys vitamins, and to elucidate the conditions favorable to vitamin retention. Kohman, for example, early emphasized the importance of excluding oxygen in the preparation of tomato juice as a means of conserving vitamin C, and suggested how this could be done *(18: XIII)*. An outgrowth of this was the first extensive vitamin C survey of the tomato juice industry, made by Sanborn *(22)*, who had been associated with Kohman.

More fundamental were the experiments proving, first, that high-temperature processing does not, as had been supposed, destroy vitamin C in the absence of oxygen, and second, that the absence of oxygen may in some cases be obtained by respiratory depletion, as in the case of apple slices held under water.

In 1937, this program was suspended. The governing bodies of the Association felt, perhaps, that all the big nuggets had been found and that the stage of diminishing returns had been reached. Also, much of the assay work still had to be done by animal feeding, which was expensive and time-consuming in proportion to the data developed. There were some who later thought it would have been wiser to continue and not lose momentum. Nevertheless, it was decided to suspend the work, and thus ended one phase prior to that which is the subject of the present account.

There was, of course, other work done on nutritive values of canned foods during that period. Between 1930 and 1940, for example, certain of the can companies established nutrition research in their own laboratories, and their contributions, both then and later, considerably extended the range of nutritional information of canned foods *(1, 2, 3, 9-17, 23)* and supplemented the results of the N.C.A.-C.M.I. program to be described below.

ORIGIN OF PRESENT PROGRAM

The period from 1937 to 1941 was an extremely active one in the advancement of nutritional science, and saw many solid contributions to knowledge both on identity of nutrients and quantitative methodology. The vitamin complexes were being broken down and the chemical identity of their constituents worked out. Microbiological and chemical assay methods were being originated and improved, replacing animal feeding in more and more instances.

[a] The Babcock-Hart Award address, presented at the General Session, the Biltmore Bowl, Fourteenth Annual Meeting of the Institute of Food Technologists, June 30, 1954, Los Angeles, California.

Thus it was becoming increasingly possible to replace older qualitative information with quantitative data, and conditions were ripening for a renewed attack on the nutritive aspects of canned foods, as well as of many others. What was needed was some sort of catalyst to initiate the reaction, and for canned foods this was supplied by the National Nutrition Conference of 1941.

By May, 1941, as many will recall, the world situation required that the United States plan seriously for national defense and, as many then believed, for war. In 1940, the operation of the Selective Service system had begun which afforded the first opportunity presented in many years to evaluate the nutritional status of the young men of America. During the first few months of operation it became apparent from physical examinations that approximately one-third of the men called for induction showed definite evidence of malnutrition, and many were rejected on this account. This fact, coupled with the necessities for development of adequate Army rations and the improvement of the national level of health, led to the calling of the National Nutrition Conference for Defense *(4)* by the late President Roosevelt. This Conference convened at Washington, D. C., on May 26, 1941. Nine hundred delegates selected from industry, labor, government, educational institutions, and various professions dealing with foods were in attendance. Included among these were many delegates associated with the canning and allied industries.

Biochemists and nutritionists associated with laboratories of the canning industry had for some time been aware of the fact that comparatively few quantitative data on the nutritive compositions of canned foods were available in the standard literature. At the Conference this fact was developed again for the delegates from the canning industry. In particular, the need for more complete information on all types of foods for use in the planning of improved civilian and military dietaries was stressed.

The impact of the National Nutrition Conference was strong enough to convince leaders in the canning industry that the time had come to revive research on nutritive values of canned foods. As the idea grew it was decided to explore with the Can Manufacturers Institute the possibility of a program under joint sponsorship of the National Canners Association and the Institute. This suggestion was well received and in a short time both organizations approved the proposal for one year's work, to be jointly financed.

The minor detail of finances having been disposed of, there arose the problem of settling on some type of administration for the proposed nutrition program. It must not be supposed that the scheme finally adopted sprang, like Athena, "fully-armed from the brow of Zeus." Instead it was preceded by a period of groping. The first possibility explored was that of persuading some agency recognized for its interest in public health to administer the program. The American Medical Association was approached to that end, but while interested in the objectives its Council on Foods and Nutrition was not organized in a way to assume such responsibilities. It did, however, suggest a number of names of well-known nutritionists who might be interested in assuming the direction of the work, and additional suggestions of this sort were received from other sources. As a collateral development, one proposal was developed that a foundation be established at a Midwestern university. This idea received serious consideration, but being based on greater assurance of a long-term program than seemed then to be forthcoming it was finally abandoned.

By this time Pearl Harbor had been attacked and in the new situation the N.C.A.-C.M.I. steering committee concluded that direction of the program would have to be effected through talent already available in the canning or allied industries. After one or two possible means of doing this had been considered and found infeasible, the decision was made to establish an Executive Nutrition Committee, which was composed of representatives of the two sponsoring organizations. With two exceptions the original members of this committee have served ever since. The members, other than the chairman, were:

Dr. E. D. Clark, National Canners Association
Dr. L. E. Clifcorn, Continental Can Co., representing C. M. I.
Dr. J. R. Esty, National Canners Association
Dr. R. W. Pilcher, American Can Co., representing C. M. I.

The writer was honored by being asked to serve as chairman of this group of men, and must give them major credit for whatever success the program has enjoyed. Due to press of other duties, Dr. Pilcher was obliged to resign in 1950, his place being taken by Dr. Randall Royce, also of the American Can Company. In April of this year, the Committee suffered a sad loss through the death of Dr. Esty. As a further contact with the sponsoring organizations, an Industry Advisory Committee was also established, consisting of 41 representatives of canning firms and container manufacturers.

Planning and execution. With finances in hand for a year's operation, and an Executive Committee to administer it, we next had to decide what tasks had best be done, and in what order. A little consideration showed that there was need for work in two distinct categories, namely:

1. Determination of the specific influences or effect of commercial canning operations on the nutrients in raw canning stocks with the ultimate purpose of improving retention of such nutrients in the final product. This phase also includes other studies of a specialized type related to improvement of the nutritive values of canned foods.
2. Establishment of the nutritive values of foods canned by modern practices with respect to their contributions of vitamins, minerals, and the proximate food components such as carbohydrate, protein, and fat.

Under normal circumstances these would have been undertaken in the order indicated. At that time, however, shortly after Pearl Harbor, there was an urgent demand from agencies charged with proper nutrition of the armed forces for more exhaustive information on the composition of all types of foods, particularly information on vitamin values. This was reflected in the appointment by the National Research Council of a Food Composition Committee to compile and tabulate information on the subject from all possible sources and especially data previously unreported by industry *(21)*. The Food Composition Committee was especially eager for data on canned foods because of their importance in military rations, and in deference to this need our program gave priority in the first year's work to establishment of the nutritive values of canned foods as then manufactured. This type of activity was designated then and afterwards as "Phase I." As the program continued into subsequent years it became possible to launch so-called "Phase II" studies, namely, the determination by modern methods of the specific effects of canning operations and other commercial and consumer practices on nutrients in raw foods and the study of means of increasing retention of these nutrients. By 1950, the eighth year of the program, Phase II activities made up the major part of the projects under way. Some of these will be described in more detail below.

Nothing has been said thus far as to the means that were to be used to get these things done, though naturally that was from the very first a vital consideration. One of the earliest decisions made was that so far as possible the greater part of the work should be done by qualified agencies not connected with the industry. This principle has with minor exceptions been followed throughout. What it meant at the outset was to enlist the interest of a number of colleges and universities outstanding for their competence in nutritional investigation, and arrange with them for the conduct of the various projects under research grants or grants-in-aid. Fortunately, the projects themselves and the general objective of the work proved attractive enough so that it was not too difficult to secure the desired collaboration.

It would be pointless to chronicle here the placing of grants or the allocation of projects to the various institutions, but in justice to the competence with which they completed their undertakings their names should be mentioned:

Cornell University (New York Agricultural Experiment Station)
Michigan Agricultural Experiment Station
Pennsylvania State College
University of Arizona
University of California, at Los Angeles
University of Chicago
University of Maryland

University of Texas
University of Wisconsin

In the main, as I have said, we adhered to the principle of allocating the work to outside institutions under grants. However, in a few instances it proved more feasible to assign certain Phase II studies to the National Canners Association Western Branch Laboratory, principally as a means of correlating the technological and laboratory aspects. Again, in certain recent studies on special dietetic packs, it has seemed most practical to have the analyses made on a fee basis by the Wisconsin Alumni Research Foundation.

Phase I—Nutrients in Canned Foods as Marketed

In the first few years emphasis was placed on a large-scale survey of canned foods with respect to the principal factors then recognized as important in human nutrition and even some whose essentiality had not yet been established. This phase had been given increased urgency by the needs of the armed services, but would have been undertaken anyway in due course.

The initial studies involved the collection and analysis of about 900 samples of commercially canned foods, representing more than 30 different products, and more were added later. In practically all instances these were simple, unformulated products. The purpose was, of course, to obtain results representative of the entire pack of each item, which would be impossible with specialties that differ in formulation from one manufacturer to another. With this limitation in number of products it was possible to study each in a comprehensive way, and yet the range of products was great enough to afford a good reflection of the nutritive value of canned foods as a group. The products studied initially included canned fruits, vegetables, and fish and marine products.

In each instance every effort was made to obtain samples that would represent the entire pack, geographically and as to variety and style of pack. The samples were collected at the canneries by representatives of the sponsoring organizations, a sampling usually representing a day's pack in one can size. As a rule, early, mid, and late season samplings were obtained from each cannery. Records were kept of the history of each sample, including raw product data and canning procedures used. Both retail and large institutional can sizes were included. These samples were marked for identification, sent to a central collection station for inspection and coding, and then sent to the different collaborators who performed the detailed examinations.

These details are cited in the hope of giving some impression of the task involved in the mere procurement, identification and distribution of samples. This involved much study and a great many man-hours. For the sampling plan itself we make no claim of perfection, but believe that our experience merits study by anyone undertaking a project of similar type and scope. One such project is now under way, a study of nutritive values of frozen foods supported by the National Association of Frozen Food Packers, and we are given to understand that our experience was of considerable value to them in formulating their own plan, which embodies a stratified scheme based on statistical sampling theory.

All foods in this main Phase I program were analyzed for proximate and mineral composition (calcium, phosphorus and iron), carotene, ascorbic acid, thiamine, riboflavin, niacin, and pantothenic acid. A selected group of products were further examined for biotin, pyridoxine, and folic acid, and a number of types of canned fish and seafood were examined for vitamins A and D. In addition, special studies were made on methods of assay and on distribution of nutrients (proximate, mineral, and water-soluble vitamins) between liquid and solid portions of canned foods.

Such a terse statement does scant justice to the volume of information developed in these studies, but obviously it would be impracticable to present the detailed figures here; one must consult the original publications both for the numerical data and for an appreciation of their extent. However, some mention should be made of the considerations that dictated the choice of nutrients to be determined, and perhaps it will be possible also to indicate in a general way the nature of the findings.

The proximate composition, of course, gives the basis for calculation of caloric value and includes protein, recommendations for both of which have been included in the recommended daily allowances of the Food and Nutrition Board of the National Research Council. Other factors listed in the R. D. A. are calcium, iron, vitamin A, thiamine, riboflavin, niacin, ascorbic acid, and vitamin D, all included in our program. In addition, it was desired to measure these foods against the Minimum Daily Requirements used by the U. S. Food and Drug Administration in appraisal of foods for special diets. Aside from differences in numerical values, these Minimum Daily Requirements differ from Recommended Daily Allowances in listing phosphorus but not protein.

Although no standard human requirements had been established for pantothenic acid, biotin, pyridoxine, or folic acid, it seemed wise to determine these on at least a representative range of canned foods against the time when their need might be better measured; pantothenic acid was assayed in the entire list of foods included in the main program.

The major part of the Phase I work was done during the earlier years of the program, but a substantial addition has been made recently *(20: XLV)* to the data on proximate composition, pyridoxine (vitamin B_6), folic acid, beta-carotene, ascorbic acid, riboflavin, and niacin. The latter project had two objectives, first to improve the representative character of the sampling, and second to utilize improved methods of assay for some of the B-vitamins.

Phase I findings. Since the survey included over 40 products (fruits, vegetables, and seafoods), and examination was made for proximate constituents, 3 minerals, and 10 vitamins, it is obviously possible here to touch only some of the high spots. Perhaps this can best be done by taking one nutrient or group of nutrients at a time.

First, however, it may be well to mention the studies on distribution of nutrients between solid and liquid portions of canned foods. A fair generalization of these results is to say that water-soluble nutrients are distributed pretty much in proportion to the weights of moisture in liquid and solid portions, while water-insoluble nutrients are concentrated in the solid portions.

The proximate analyses, of course, disclosed nothing especially surprising, since data of this type have been available for a long time. However, because of the detailed history of each sample it was possible to study variations within a given commodity and trace the effects of such factors as maturity. The protein content of starchy vegetables, for example, increases with maturity, as do the thiamine content of peas and the phosphorus content of seed vegetables.

The mineral analyses showed, as would be expected, that seafoods were leading in contributions of calcium and phosphorus, as they had been in protein. When products were ranked in order of iron content the 4 leaders were blueberries, kraut, sardines in tomato sauce, and turnip greens. Rather a mixed bag, but the entire range was from a few tenths to a little over 5 p.p.m. Some foods in metal containers may pick up traces of iron from the container. Such iron is physiologically available but it tends to confuse the analytical picture so far as obtaining values characteristic of the food is concerned.

Some of the other nutrients will be commented upon separately:

Ascorbic Acid. The outstanding products were peppers and pimientos, both having over 100 mg. per 100 g. These are, of course, not eaten in great quantity and we have to look further down the list of fruits and vegetables for important dietary sources. Of 35 fruits and vegetables tabulated, 14 had more than 10 mg. per 100 g. In products with solid and liquid portions the ascorbic acid was mostly associated with the solid portion, but the liquid was well worth utilizing both for its ascorbic acid and other water-soluble nutrients.

Carotene and Vitamin A. These are probably the least affected of any of the vitamins by canning operations. They are almost entirely retained in the solid portion, with the exception that the vitamin A of canned fish may be extracted to some small extent into the liquid packing medium. The best sources were carrots, sweetpotatoes, spinach, and turnip greens, though half a dozen or so other fruits and vegetables ranked as good sources.

Vitamin D. Since fruits and vegetables are known to contain little or no vitamin D they were not assayed. Representative canned fish, namely, mackerel, salmon, tuna, and sardines, were all shown to be excellent sources.

Thiamine. None of the vegetables, fruits, or fish products studied are outstanding sources of thiamine, whether in the raw, cooked, or canned forms, on the basis of absolute content. However, average servings of many of the canned foods furnished from 1 to 14% of minimum daily requirements, which might be considered as a dividend on their other values. Canned peas, for example, furnish 11 to 13%, orange juice 9 to 14, pineapple and tomato juices 6 to 10, and asparagus 7% of minimum daily requirements, in average servings.

Riboflavin. Riboflavin is more stable to heat than thiamine and is better retained in canning. A disproportionate amount is retained in the solid portions of vegetables, though the liquid contains worthwhile quantities. Canned fish and mushrooms lead off the list in absolute amount as well as in contribution to recommended daily allowances.

Niacin. With minor exceptions, what is true of riboflavin is true of niacin. Here again the seafoods lead, giving even greater contributions to the daily allowances or requirements. Tuna, for example, in a 3.5 ounce serving, furnishes 70% of the recommended daily allowance, or 100% of the minimum daily requirement.

Use of Phase I findings. It will be recalled that this work on the nutritive values of canned foods as commercially produced was given priority in our program because of the need for more adequate data for use by the armed forces. In recognition of this, the data were turned over in advance of publication to the Food Composition Committee of the National Research Council, who incorporated the information on canned food with that on other classes of foods in tables furnished to the armed services.

As in the other phases of the program, the original investigators in each case published their findings in scientific and professional journals *(20)*. Since this, however, tended to scatter the information both as to location and time, there was need for some means of presenting it in a unified fashion.

This was accomplished to some degree in a series of popular pamphlets issued by the Can Manufacturers Institute, "Nutrition in a Nutshell," "On-the-table Values in Canned Foods," and "Canned Foods in the Nutritional Spotlight." The first of these presented general information briefly without numerical data, the other two giving a series of bar charts and tables summarizing the data.

In order to develop more fully the value of the results of such a comprehensive program, the Nutrition Executive Committee decided to compile a reference book embodying the results of these studies together with such background information as would give a clear idea of the nutritive values of canned foods and the best means of conserving and utilizing these values. This book *(7)*, entitled *Canned Foods in Human Nutrition*, was published in 1950 by the National Canners Association, and has received a wide distribution among nutritionists, dietitians, physicians, and other professions having to do with food.

Canned Foods in Human Nutrition is a book of 264 pages, having 16 chapters divided into 3 sections dealing with modern concepts of nutrition, nutritive values of canned foods, and storage and utilization of canned foods, respectively. An appendix of 11 tables, a bibliography, and an index complete the volume. In the tables the amounts of nutrients are shown not only in absolute terms but as percentages of Recommended Daily Allowances and of Minimum Daily Requirements.

Aiming at a wider audience, the N. C. A. Home Economics Division has prepared a loose-leaf folder entitled "Canned Food Tables" one side of which is a table of nutrients in terms of average size servings of fruits, juices, vegetables and fish, the other side giving servings per container for a wide range of products and container sizes. These tables have proved immensely popular, about 4 million copies having been distributed up to now.

OTHER PHASES OF PROGRAM

In this description of our survey of nutrients in canned foods, the results obtained, and what was done with them, I have spoken of this part of the job as Phase I. In our original objectives Phase II was envisioned as the establishment of quantitative effects of canning upon nutrients in common foods. While these terms served the convenience of the Executive Committee, the actual development of the two phases was not as sharply separated as the terms might suggest, certainly not in sequence of time.

At any rate, we were interested in two broad aspects of the nutritive values of canned foods. One was the status of commercially canned foods as they are now found in the market, and this has been covered in the foregoing sections. The other was, in general terms, to account for the values found and to identify the factors that might cause these nutritive values to be what they are, or greater or smaller. Behind this lay the hope of discovering how any unnecessary loss of nutrients might be overcome by advances in raw product handling, canning procedures, distribution and storage, or final preparation for serving.

This sounds like a big order, and of course it is. We have tried to avoid biting off more than we could chew, and in some cases we have probably only nibbled. As in all research, the results serve to demonstrate how much more remains undone, but in the main we feel that we have set and reached reasonable goals.

Factory studies. A large part of our so-called Phase II work has been devoted to factory studies aimed at determining the effect of canning and of specific operations in canning on the retention of nutrients originally present in the food. There is a temptation to insert at this point a series of tables and charts giving the percent retention of various vitamins in various canned foods, both as over-all retention and to show the effect of blanching, processing, etc. That would unduly lengthen this presentation, and besides much of this material has been summarized by Cameron, Pilcher, and Clifcorn *(8)*, and in the book *Canned Foods in Human Nutrition (7)*. It will be possible only to cite a few specimen facts.

The publications just referred to present the over-all retentions of ascorbic acid, carotene, niacin, riboflavin, and thiamine in a list of products which include apricots, asparagus, carrots, corn, green beans, Lima beans, orange juice, peaches, peas, spinach, tomatoes and tomato juice. (Not all vitamins in all products.) The general conclusion was drawn that canned foods retain a large part of their original nutritive values; obviously, however, such a statement obscures the individual variations that lend interest to the results.

One source of such variations, in the case of certain vegetables, is the necessity for blanching, an operation in which some sacrifice of water-soluble vitamins may occur. Five typical vegetables (asparagus, green beans, Lima beans, peas, and spinach) were chosen for studies of this operation in its effect on ascorbic acid, niacin, riboflavin, and thiamine. It was found, for example, that asparagus had the best retention of ascorbic acid (average 95%) while spinach had the lowest and most variable (average 67%). This contrast is probably in part a function of the relative surface areas through which leaching can take place. Another interesting observation was that niacin, although water-soluble, is more firmly bound in the product than ascorbic acid and is better retained in blanching.

For studies on effect of thermal processing, thiamine was the nutrient of choice because of its heat-lability. In 5 vegetables and tomato juice retentions during heat processing ranged from 31% to 89%, reflecting in general the degree of severity of process required for sterilization of the several products. It has been shown, however, by Feaster, Tompkins, and Ives *(13)* that processes of like sterilizing value at different temperatures are not alike in their effect on thiamine, the difference being in favor of high temperature-short time processing, a method which is finding increasing application each year.

Storage studies. Rather early in the program, studies on the effect of prolonged storage at constant temperatures were begun, wherein a broad range of fruits and vegetables were stored up to two years at 50°, 65°, and 80° F., with initial and periodic determinations of ascorbic acid, carotene, thiamine, riboflavin, and niacin. The results have been summarized in *Canned Foods in Human Nutrition (7)*, and indicate reasonably good stability at moderate temperatures, say up to 70° F., even for the more labile of the vitamins. At the highest temperature, 80° F., losses ranged from slight to rather severe. Such temperatures are recognized as undesirable for other reasons as well as that of nutrient retention.

These findings led to the adoption of a project to determine actual temperature patterns in commercial canned food warehouses throughout the United States, and also to measure vitamin retention in canned foods under known warehousing conditions. The vitamin retention values found were consistent with those in constant temperature storage, while the temperature distribution studies brought out the interesting fact that even in the hottest areas of the South the average yearly warehouse temperature did not exceed 80° F. In areas where the most canned food is warehoused, yearly averages are about 65° F. These findings, we think, justify the choice of 80° F. as a maximum temperature for sustained storage tests of this kind, at any rate where the results are expected to apply to domestic conditions and not those of the tropics.

Preparation for serving. Recognizing that "the proof of the pudding is in the eating," our very first year's program included studies on the effect on vitamin retention of large-scale and small-scale preparation for serving. Obviously this concerns canned vegetables more than canned fruits or seafoods, since the latter are eaten pretty much as they come from the can. The vegetables, on the other hand, are generally heated for various lengths of time before serving, and there is also the question of what one does with the liquid portions, which, as we have seen, contain sizeable amounts of the water-soluble nutrients. This latter factor is of more concern than the amount of heating; in general the nutrients in the liquid can be utilized either by boiling it down and serving it with the solids, or by using it in soups or gravy. In institutional practice, we grant that this is seldom done. Moreover, the practice of serving from the steam table with slitted spoons leaves behind valuable nutrients as well as flavor which should be utilized.

Protein and Amino Acids

One project which had some attributes both of Phase I and Phase II in our program was that of determining the amino acids of typical high-protein canned foods and the effect of the canning operation upon them.

Perhaps we would not have undertaken this project had it not been for the advances being made in the evaluation of proteins with respect to their biological value and the functions of their constituent amino acids. It is true that the early work of Osborne and Mendel had shown the differences in value of different proteins and the role of some of the amino acids, but it was really the work of later investigators such as W. C. Rose on the essential amino acids, and of M. S. Dunn, F. M. Strong, and their associates on microbiological assay of amino acids that gave a background detailed enough to warrant our including this investigation in our program. There was by this time a good methodology of amino acid assay, and uniformity of understanding as to the amino acids essential for human nutrition.

Our studies embraced 8 canned fish items and 3 canned meats, all but one of which were examined both in the raw or precooked state as well as after canning. The analyses were duplicated in two widely separated institutions *(20: XXXIII)*, but the results showed remarkable agreement throughout, fully vindicating faith in the reliability and precision of the microbiological methods employed.

Analyses were made in all instances for 13 amino acids, including the eight regarded as essential in human nutrition. From the retention standpoint, the results showed practically identical values before and after canning. Whether this identity is fully reflected in biological availability we do not know, but the results do tend to confirm the high nutritive value of the proteins of these canned foods.

Expressing the content of the 8 essential amino acids as percentages of recommended daily intakes, it appears that the fish and meat proteins were about on a par throughout. Particularly notable were the high proportions of the requirements which canned fish provide with respect to isoleucine, lysine, and threonine, an average serving giving up to 132% of recommended daily intake in some instances. The lowest values were for methionine, ranging from 16 to 33%. Clearly, a single serving of any of these foods supplies substantial quantities of all the essential amino acids as well as of the total protein needs of the adult.

DIETETIC CANNED FOODS

The most recent major phase of our nutrition program has been devoted to the composition of canned foods packed for special dietary purposes, that is to say, foods suitable for low-calorie, low-carbohydrate, or low-sodium diets. In effect this means canned foods packed without added sugar, salt, or incidental sodium pickup.

The production and use of these dietetic canned foods has been increasing rapidly in recent years, until now it is common to see special sections devoted to them in grocery stores and supermarkets. The total production in 1951 was estimated at 5 million cases; later figures are not available.

This phenomenal expansion, however, was not yet in evidence in 1949 when we first embarked on work on dietetic foods. As a matter of fact our interest was first attracted to this subject by the growing demand for data on sodium content of foods, due to the value placed on sodium restriction in medical treatment of hypertension. It soon became apparent that any investigation of these foods should cover their proximate composition as well as sodium content, if the results were to be useful in guiding the industry in the production and labeling of these foods, and to consumers in using them.

For the first year's undertaking some 150 samples of experimentally water-packed fruits and vegetables were assayed for proximate composition and content of sodium and potassium. The water used in canning these experimental packs was also analyzed for sodium, since it was known that potable waters vary considerably in that respect. Thirty-one products were included in the sampling program for this first year.

When the results were reviewed it was seen that sufficiently consistent sodium values were not available to establish reliable ranges and averages for most of the products included. It was concluded that special precautions are necessary, particularly with some products, to avoid contamination with sodium during processing. Consequently, the program was elaborated to that end

and extended another year. Most of the products were resampled, some new ones were added, and particular attention was given to eliminating inadvertent sources of sodium contamination. Such sources were listed as:

1. The use of high sodium water as packing medium.
2. The use of blanch and flume water high in sodium initially or as the result of pickup from other sources.
3. The use of lye for peeling.
4. The use of salt brine for quality separation.
5. The treatment of cut fruit with dilute salt solutions to prevent discoloration.

All of these sources were incriminated in the initial survey as accounting at times for abnormally high sodium values.

The results of the two series of analyses have been presented in a bulletin *(6)* published by the National Canners Association in 1953, entitled "Dietetic Canned Foods." In addition to the data on proximate composition and sodium content it presents information on special diets and their functions, precautions to be taken in canning to avoid inadvertent contamination with sodium, and, of special importance, suggestions for proper labeling to comply with requirements of the Food, Drug, and Cosmetic Act. Since labels of foods for special dietary purposes must bear analytical information supporting the claims made, there arises the question of a testing program for the canner of such foods, and the bulletin endeavors to deal with this problem also.

Most recently we have extended the analytical survey of special dietary canned foods to commercial packs, both as a check on earlier results and as a service to canners. The analytical results of this survey have now been completed but have not yet been studied and summarized. All of the analyses in this project were performed at the Wisconsin Alumni Research Foundation.

CONCLUSION

It has been attempted to give here in small compass some idea of a nutrition research program that has now been under way for 12 years, has occupied workers in 14 laboratories in addition to those who planned and administered the program, has yielded a series of 45 original scientific contributions, a textbook and numerous other publications, and has provided a body of information on the nutritive values of canned food probably more extensive than that available on any other class of foods. Only the main outlines of the program have been included here; many details might have been mentioned, perhaps more interesting than those that were.

While those of us who have been in general charge of this program feel a natural satisfaction in its progress thus far, we realize fully that the real credit for results accomplished belongs to the skilled and intelligent people who have carried the individual projects to completion. Their knowledge and suggestions gave shape to the program at every stage. The planning of this work owes much also to the helpful suggestions given freely by nutritionists in other fields, experienced in the organization and administration of research, who took an interest in the success of the canned foods program. To all these people we express our gratitude and the hope that the results have justified their interest.

LITERATURE CITED

1. Alexander, O. R., and Feaster, J. F. Thiamine and ascorbic acid values of raw and canned peas. *Food Research*, **12**, 468 (1947).
2. American Can Company, Nutrition Laboratory, Research Div. *Nutritive Aspects of Canned Foods*. 110 pp. (1937).
3. American Can Company, Research Div. *Canned Food Reference Manual*. First ed. (1937), second ed. (1943), third ed. (1947).
4. Anon. Proceedings of the National Nutrition Conference for Defense, May 26, 27, and 28, 1941. Federal Security Agency (1942).
5. Atwater, W. O., and Bryant, A. P. The chemical composition of American food materials. U. S. Dept. of Agr. *Bull. 28* (Revised) (1906).
6. Bing, F. C. (Editor). Dietetic canned foods. 62 pp. Nat. Canners Assoc. (1953).
7. Cameron, E. J., and Esty, J. R. (Editors). *Canned Foods in Human Nutrition*. 264 pp. Nat. Canners Assoc. (1950).
8. Cameron, E. J., Pilcher, R. W., and Clifcorn, L. E. Nutrient retention during canned food production. *Am. J. Public Health*, **39** (6), 756 (1949).
9. Clifcorn, L. E. Factors influencing the vitamin content of canned foods. *Advances in Food Research*, **1**, 39 (1948).
10. Clifcorn, L. E., and Heberlein, D. C. Thiamine content of vegetables, effect of commercial canning. *Ind. Eng. Chem.*, **36**, 168 (1944).
11. Clifcorn, L. E., and Peterson, G. T. The retention of vitamin C in tomato juice. Nat. Canners Assoc. *Information Letter* No. 1120 (Suppl.), January 31 (1947).
12. Feaster, J. F., Braun, O. G., Riester, D. W., and Alexander, P. E. Influence of storage conditions on ascorbic acid content and quality of canned orange juice. *Food Technol.*, **4**, 190 (1950).
13. Feaster, J. F., Tompkins, M. D., and Ives, M. Influence of processing techniques on vitamin retention. *Canner*, **104** (11), 16 (1947).
14. Feaster, J. F., Tompkins, M. D., and Ives, M. Retention of vitamins in low acid canned foods. *Food Inds.*, **20** (1), 82 (1948).
15. Feaster, J. F., Tompkins, M. D., and Pearce, W. E. Effect of storage on vitamins and quality in canned foods. *Food Research*, **14**, 25 (1949).
16. Heberlein, D. G., Ptak, L. R., Bendix, G. H., and Clifcorn, L. E. Factors influencing the stability of thiamine during heat sterilization. *Food Research*, **16**, 494 (1951).
17. Jackson, J. M., Feaster, J. F., and Pilcher, R. W. The effect of canning procedures on vitamins in foods. *Proc. Inst. Food Technol.*, 81 (1945).
18. Kohman, E. F., Eddy, W. H., *et al.* Nat. Canners Assoc.—Columbia Univ. *Nutrition Series:*
    - Eddy, W. H., and Kohman, E. F. I. Vitamin C in canned foods. *Ind. Eng. Chem.*, **16**, 52 (1924).
    - Kohman, E. F., Eddy, W. H., and Carlsson, V. Vitamins in canned foods. II. The vitamin C destructive factor in apples. *Ind. Eng. Chem.*, **16**, 1261 (1924).
    - Eddy, W. H., Kohman, E. F., and Carlsson, V. Vitamins in Canned Foods. III. Canned spinach. *Ind. Eng. Chem.*, **17**, 69 (1925).
    - Eddy, W. H., Kohman, E. F., and Carlsson, V. Vitamins in canned foods. IV. Green peas. *Ind. Eng. Chem.*, **18**, 85 (1926).
    - Kohman, E. F., Eddy, W. H., Carlsson, V., and Halliday, N. Vitamins in canned foods. V. Peaches. *Ind. Eng. Chem.*, **18**, 302 (1926).
    - Kohman, E. F., Eddy, W. H., and Halliday, N. Vitamins in canned foods. VI. Strawberries. *Ind. Eng. Chem.*, **20**, 202 (1928).
    - Eddy, W. H., Kohman, E. F., and Halliday, N. Vitamins in canned foods. VII. Effect of storage on vitamin value of canned spinach. *Ind. Eng. Chem.*, **21**, 347 (1929).
    - Kramer, M. M., Eddy, W. H., and Kohman, E. F. Vitamins in canned foods. VIII. Home canning and commercial canning contrasted in their effects on vitamin values of pears. *Ind. Eng. Chem.*, **21**, 859 (1929).
    - Kohman, E. F., Eddy, W. H., and Zall, C. Vitamins in canned foods. IX. Tomato products. *Ind. Eng. Chem.*, **22**, 1015 (1930).
    - Kohman, E. F., Eddy, W. H., and Gurin, C. Z. Vitamins in canned foods. X. The vitamin content of some canned vegetables. *Ind. Eng. Chem.*, **23**, 808 (1931).
    - Kohman, E. F., Eddy, W. H., and Gurin, C. Z. Vitamins in canned foods. XI. A canned food diet. *Ind. Eng. Chem.*, **23**, 1064 (1931).
    - Eddy, W. H., Gurin, C. Z., and Kohman, E. F. Vitamins in canned foods. XII. Supplementary nature of grapefruit and prunes. *Ind. Eng. Chem.*, **24**, 457 (1932).
    - Kohman, E. F. Stabilizing nutrients by canning. *Ind. Eng. Chem.*, **24**, 650 (1932).
    - Kohman, E. F., Eddy, W. H., and Gurin, C. Z. Vitamins in canned foods. XIII. Canning tomato juice without vitamin C loss. *Ind. Eng. Chem.*, **25**, 682 (1933).
    - Kohman, E. F., Sanborn, N. H., Eddy, W. H., and Gurin, C. Z. Vitamins in canned foods. XIV. Calcium and vitamin D in foods. *Ind. Eng. Chem.*, **26**, 758 (1934).
    - Kohman, E. F., Eddy, W. H., White, M. E., and Sanborn, N. H. Comparative experiments with canned, home cooked and raw food diets. *J. Nutrit.*, **14**, 9 (1937).

KOHMAN, E. F., EDDY, W. H., WHITE, M. E., AND SANBORN, N. H. The antirachitic effect of some foods. *Food Research*, **3**, 373 (1938).

19. KOHMAN, E. F. Vitamins in canned foods. Nat. Canners Assoc. *Bull.* 19-L (1922).

20. National Canners Association-Can Manufacturers Institute nutrition program series: The nutritive value of canned foods.
I. CLIFCORN, L. E. Introduction and sampling procedure. *J. Nutrit.*, **28**, 101 (1944).
II. PRESSLEY, A., RIDDER, C., SMITH, M. C., AND CALDWELL, E. Ascorbic acid and carotene or vitamin A content. *J. Nutrit.*, **28**, 107 (1944).
III. IVES, M., WAGNER, J. R., ELVEHJEM, C. A., AND STRONG, F. M. Thiamine and niacin. *J. Nutrit.*, **28**, 117 (1944).
IV. THOMPSON, M. L., CUNNINGHAM, E., AND SHELL, E. E. Riboflavin and pantothenic acid. *J. Nutrit.*, **28**, 123 (1944).
V. BRUSH, M. K., HINMAN, W. F., AND HALLIDAY, E. G. Distribution of water soluble vitamins between solid and liquid portions of canned vegetables and fruits. *J. Nutrit.*, **28**, 131 (1944).
VI. HINMAN, W. F., BRUSH, M. K., AND HALLIDAY, E. G. Effect of large-scale preparation for serving on the ascorbic acid, thiamin, and riboflavin content of commercially-canned vegetables. *J. Am. Dietet. Assoc.*, **20**, 752 (1944).
VII. HINMAN, W. F., BRUSH, M. K., AND HALLIDAY, E. G. Effect of small-scale preparation for serving on the ascorbic acid, thiamin, and riboflavin content of commercially-canned vegetables. *J. Am. Dietet. Assoc.*, **21**, 7 (1945).
VIII. KRAMER, A. Distribution of proximate and mineral nutrients in the drained and liquid portions of canned vegetables. *J. Am. Dietet. Assoc.*, **21**, 354 (1945).
IX. WAGNER, J. R., IVES, M., STRONG, F. M., AND ELVEHJEM, C. A. Effect of commercial canning and short-time storage on ascorbic acid content of grapefruit juice. *Food Research*, **10**, 469 (1945).
X. IVES, M., ZEPPLIN, M., AMES, S. R., STRONG, F. M., AND ELVEHJEM, C. A. Further studies on riboflavin, niacin, and pantothenic acid. *J. Am. Dietet. Assoc.*, **21**, 357 (1945).
XI. GUERRANT, N. B., VAVICH, M. G., AND FARDIG, O. B. Comparison of vitamin values obtained by different methods of assay. *Ind. Eng. Chem., Anal. Ed.*, **17**, 710 (1945).
XII. VAVICH, M. G., STERN, R. M., AND GUERRANT, N. B. Determination of ascorbic acid of fresh green peas. *Ind. Eng. Chem., Anal. Ed.*, **17**, 531 (1945).
XIII. GUERRANT, N. B., VAVICH, M. G., AND DUTCHER, R. A. Influence of temperature and time of storage on vitamin contents. *Ind. Eng. Chem.*, **37**, 1240 (1945).
XIV. WAGNER, J. R., STRONG, F. M., AND ELVEHJEM, C. A. Effect of commercial canning operations on the ascorbic acid, thiamine, riboflavin, and niacin contents of vegetables. *Ind. Eng. Chem.*, **39**, 985 (1947).
XV. WAGNER, J. R., STRONG, F. M., AND ELVEHJEM, C. A. Effects of blanching on the retention of ascorbic acid, thiamine, and niacin in vegetables. *Ind. Eng. Chem.*, **39**, 990 (1947).
XVI. KRAMER, A. Proximate and mineral composition. *Food Research*, **11**, 391 (1946).
XVII. IVES, M., POLLARD, A. E., ELVEHJEM, C. A., AND STRONG, F. M. Pyridoxine, biotin, and "folic acid." *J. Nutrit.*, **31**, 347 (1946).
XVIII. HINMAN, W. F., HIGGINS, M. M., AND HALLIDAY, E. G. Further studies on carotene, ascorbic acid, and thiamine. *J. Am. Dietet. Assoc.*, **23**, 226 (1947).
XIX. LAMB, F. C. Factors affecting ascorbic acid content of canned grapefruit and orange juices. *Ind. Eng. Chem.*, **38**, 860 (1946).
XX. GUERRANT, N. B., VAVICH, M. G., FARDIG, O. B., DUTCHER, R. A., AND STERN, R. M. Changes in the vitamin content of foods during canning. *J. Nutrit.*, **32**, 435 (1946).
XXI. LAMB, F. C., PRESSLEY, A., AND ZUCH, T. Retention of nutrients during commercial production of various canned fruits and vegetables. *Food Research*, **12**, 273 (1947).
XXII. MOSCHETTE, D. S., HINMAN, W. F., AND HALLIDAY, E. G. Effect of time and temperature of storage on vitamin content of commercially canned fruits and fruit juices. (Stored 12 months). *Ind. Eng. Chem.*, **39**, 994 (1947).
XXIII. GUERRANT, N. B., VAVICH, M. G., FARDIG, O. B., ELLENBERGER, H. A., STERN, R. M., AND COONEN, N. H. Effect of duration and temperature of blanch on vitamin retention by certain vegetables. *Ind. Eng. Chem.*, **39**, 1000 (1947).
XXIV. KRAMER, A., AND SMITH, M. H. Effect of duration and temperature of blanch on proximate and mineral composition of certain vegetables. *Ind. Eng. Chem.*, **39**, 1007 (1947).
XXV. NEILANDS, J. B., STRONG, F. M., AND ELVEHJEM, C. A. Vitamin content of canned fish products. *J. Nutrit.*, **34**, 633 (1947).
XXVI. SHEPT, B. B., GRISWOLD, R. M., TARLOWSKY, E., AND HALLIDAY, E. G. Effect of time and temperature of storage on vitamin content of commercially canned fruits and fruit juices (Stored 18 and 24 months). *Ind. Eng. Chem.*, **41**, 144 (1949).
XXVII. GUERRANT, N. B., FARDIG, O. B., VAVICH, M. G., AND ELLENBERGER, H. A. Influence of temperature and time of storage on vitamin content. *Ind. Eng. Chem.*, **40**, 2258 (1948).
XXVIII. MONROE, K. H., BRIGHTON, K. W., AND BENDIX, G. H. Some studies of commercial warehouse temperatures with reference to the stability of vitamins in canned foods. *Food Technol.*, **3**, 292 (1949).
XXIX. HERZBERLEIN, D. G., PTAK, L. R., MEDOFF, S., AND CLIFCORN, L. E. Quality and nutritive value of peas as affected by blanching. *Food Technol.*, **4**, 104 (1950).
XXX. MARSHALL, R. E., AND ROBERTSON, W. F. I. Handling and storage procedures for vegetables prior to canning. *Food Technol.*, **2**, 133 (1948).
XXXI. FRASTER, J. F., MUDRA, A. E., IVES, M., AND TOMPKINS, M. D. Effect of blanching time on vitamin retention in canned peas. *The Canner*, **108** (1), 27 (1949).
XXXII. PAUL, P., EINDECKER, B., KELLEY, L., JACKSON, M., JACKSON, L., MARSHALL, R. E., ROBERTSON, W. F., AND OHLSON, M. A. II. Changes in ascorbic acid of vegetables during storage prior to canning. *Food Technol.*, **3**, 228 (1949).
XXXIII. DUNN, M. S., CAMIEN, M. N., EIDUSON, S., AND MALIN, R. B. I. Amino acid content of fish and meat products. *J. Nutrit.*, **39**, 177 (1949).
XXXIII. NEILANDS, J. B., SIRNY, R. J., SOHLJELL, I., STRONG, F. M., AND ELVEHJEM, C. A. II. Amino acid content of fish and meat products. *J. Nutrit.*, **39**, 187 (1949).
XXXV. LAMB, F. C., LEWIS, L. D., AND LEE, S. K. Effect of blanching on retention of ascorbic acid and thiamine in peas. *Western Canner and Packer*, **40** (6), 60 (1948).
XXXVIII. INGALLS, R., BREWER, W. D., TOBEY, H. L., PLUMMER, J., BENNETT, B. B., AND OHLSON, M. A. III. Changes in riboflavin content of vegetables during storage prior to canning. *Food Technol.*, **4**, 258 (1950).
XXXIX. ROBINSON, W. B., MOYER, J. C., AND KERTESZ, Z. I. "Thermal maceration" of plant tissue. *Plant Physiol.*, **24**, 317 (1949).
XL. INGALLS, R., BREWER, W. D., TOBEY, H. L., PLUMMER, J., BENNETT, B. B., AND PAUL, P. IV. Changes in thiamine content of vegetables during storage prior to canning. *Food Technol.*, **4**, 264 (1950).
XLI. KELLEY, L., BENNETT, B. B., RAFFERTY, J. P., AND PAUL, P. V. Changes in carotene content of vegetables during storage prior to canning. *Food Technol.*, **4**, 269 (1950).
XLII. CHITRE, R. G., WILLIAMS, J. N. JR., AND ELVEHJEM, C. A. A study of the protein value of young and mature peas (Pisum Sativum). *J. Nutrit.*, **42**, 207 (1950).
XLIII. LAMB, F. C., LEWIS, L. D., AND WHITE, D. G. The effect of storage on the ascorbic acid content of canned tomato juice and tomato paste. *Food Technol.*, **5**, 269 (1951).
XLIV. PAUL, P. C., ROBERTSON, W. F., CASE, W. H., AND MARSHALL, R. E. Enzyme inactivation and ascorbic acid retention in vegetables blanched and held under different conditions prior to canning. *Food Technol.*, **6**, 464 (1952).
XLV. TEPLY, L. J., DERSE, P. H., KRIEGER, C. H., AND ELVEHJEM, C. A. Vitamin B_{12}, folic acid, beta-carotene, ascorbic acid, thiamine, riboflavin, and niacin content and proximate composition. *J. Agr. Food Chem.*, **1**, 1204 (1953).

21. PAYCEK, P. L., AND ELVEHJEM, C. A. Work of the Committee on Food Composition. *J. Am. Dietet. Assoc.*, **20**, 216 (1944).

22. SANBORN, N. H. Conservation of vitamin C in tomato juice production. *Canning Trade*, **60** (28), 96 (1938).

23. STRODTZ, N. H., BLUMER, T. E., AND CLIFCORN, L. E. The retention of carotene during the canning of tomato juice. *Food Technol.*, **6**, 299 (1952).

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The Institute invites your professional association with this select group of scientific and technological workers. Only those who are qualified by education, special training, or experience are extended this invitation.

Food Technology may be defined as the application of science and engineering to the production, processing, packaging, distribution, preparation and utilization of foods. Scientists, technologists and engineers engaged in Food Technology, executives, officials and supervisors under whose jurisdiction Food Technology operations are conducted, research investigators, teachers, and others working in the field of Food Technology, will find membership in the Institute worth many times its modest cost.

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OBJECTIVES

The Institute is a non-profit, professional, educational association to promote the application of science and engineering to the production, processing, packaging, distribution, preparation, and utilization of foods; it stimulates investigations into technological problems arising therein, it provides a medium for presenting and discussing the results of such investigations; it stimulates and provides means for the free interchange of technological information and ideas among food technologists; it promotes recognition of the role of food technologists in the technical direction of operations in these fields; all of these activities have the ultimate objective of providing better and adequate foods for mankind.

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Organized July 1, 1939, at Cambridge, Mass., with a membership of less than 100, the Institute has grown to more than 4,000 (1954). It is world-wide in scope, with members in North, Central, and South Americas, the Scandinavian countries, England, Holland, Germany, France, India, Australia, and New Zealand.

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Professional Members. Any person who is ethically qualified, and who has had training and experience in food technology, or any person who in the opinion of the Council is recognized as distinguished in the contributing sciences as they apply to foods, shall be eligible to be a Professional Member of the Institute. The minimum training which shall qualify a candidate for eligibility for Professional Member is, in general, graduation from a college, university, or similar institution in which he has majored in one or more of the sciences or branches of engineering associated with food technology. The minimum experience shall be three years experience in food technology. The Council may, at its discretion, waive any or all of the foregoing requirements in the case of a person who, thru long experience, has distinguished himself in the field of food technology.

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FOOD TECHNOLOGY, issued monthly, is the official journal of the Institute. It is published to advance the profession of food technology by disseminating the results of research and their practical application in industry. Contributors to its pages represent many fields of scientific and technological interest.

FOOD RESEARCH, published bi-monthly, is devoted to publication of the results of original investigations and occasional reviews in the fields of food and beverage technology, chemistry, and microbiology. FOOD RESEARCH is available to Institute members at the special rate of $7.50 per year.

REGIONAL SECTIONS

Where sufficient members (25 or more) live within commuting distance of a given point, a Regional Section may be established. Such Sections are able to hold meetings at more frequent intervals than the National group, thus affording the food technologists regular opportunities for an exchange of views and ideas with others in the area. There are presently 23 Regional Sections.

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Each year one of the regional sections acts as host to the Institute at an annual meeting. The program of this annual conference is designed to acquaint members with various phases of food production, processing and distribution, and to keep them abreast of current trends and technological developments. The speakers invited are those whose subjects will build a well-rounded program, of interest to the greatest number. Annual conferences are highlighted by exhibits of new equipment, processes and special ingredients.

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ERRATA

FOOD TECHNOLOGY *8* (*2*) p. 113: lines *22-26*, first column, are out of position; these lines properly follow line 40, first column.

FOOD TECHNOLOGY *8* (5) p. 263: Standard acknowledgment that the work reported on dehydrated potato granules was sponsored by the Quartermaster Food and Container Institute for the Armed Forces was inadvertently omitted.

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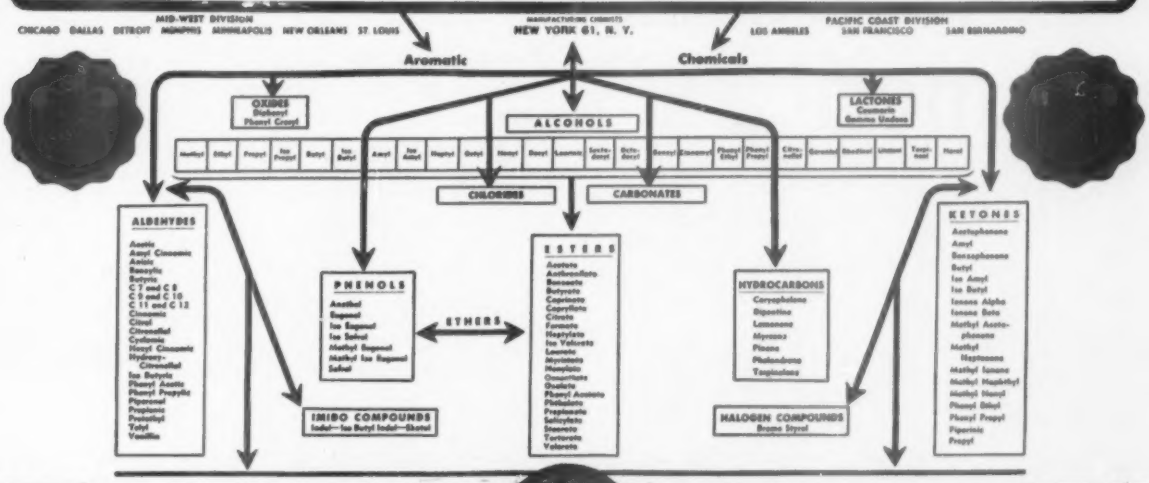

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FOOD INDUSTRY TOPICS

(Continued from page 26)

Truck Division, Clark Equipment Co., Battle Creek, Mich.

◆ ◆ ◆

Transfer of a wide variety of chemicals, gases, and liquid food products is facilitated by a **new type of flexible hose** developed by the Plastiflex Co., Santa Monica, Calif. The hose is made from two plies of polyethylene film which enclose a spiral of stainless steel wire. Where additional reinforcement is desired, the hose may be armored with flexible stainless steel braid or with a heavy plastic. According to its manufacturers, Plastiflex hose retains extreme lightness, flexibility, chemical resistance, and durability over a wide temperature range. Polyethylene film used in the hose is "Visqueen" made by the Visking Corp., Plastics Div., Terre Haute, Ind.

◆ ◆ ◆

A machine described as the first and only **movable vacuum pump unit** now available has been developed by the Vacuum Forming Corp., 76 S. Bayles Ave., Port Washington, N. Y. Called the VacForm Mobile Pump Wagon, the unit is housed in a protective metal cabinet with removable panels, mounted on a heavy steel frame with a swing-back top-door opening for convenience. When the VacForm is pushed into place, it is connected by a heavy-duty hose to whatever equipment is to be used in the vacuum application—presses, sealers, concentrators, driers, molding units, etc. Adaptable to varying electrical requirements, it is then merely plugged into an ordinary electrical connection and is ready for action. The unit weighs 900 pounds, is 3½ feet high, and requires only 4 x 2½ feet of floor space.

◆ ◆ ◆

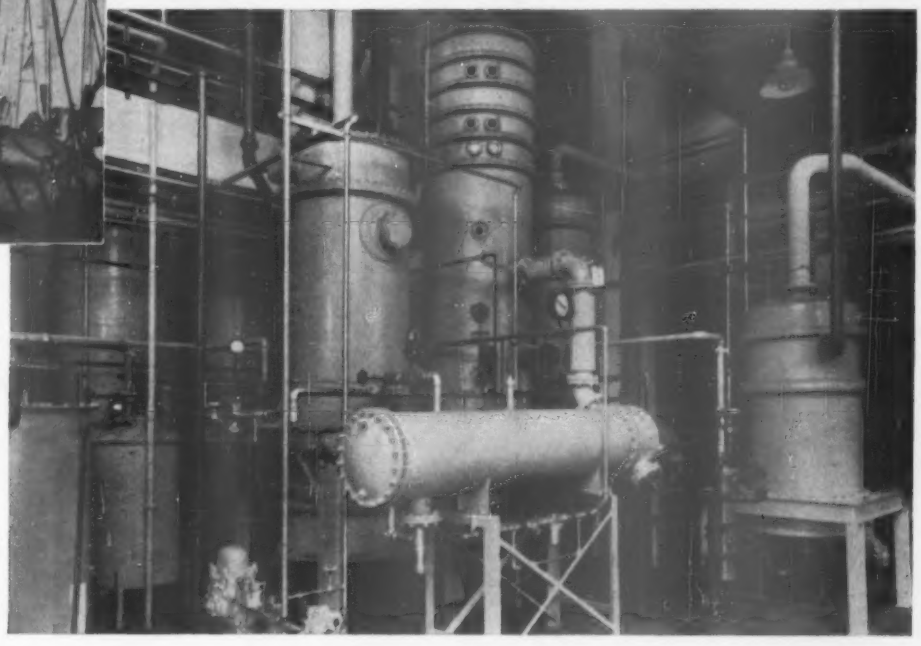
An important new development in packaging a wide range of drugs, foods, and chemicals was made known recently by Bradley Container Corp., Maynard, Mass., when it announced that it is in full commercial production on the **first polyethylene tube** manufactured in this country. Mr. Bradley Dewey, founder and president of the year-old Maynard firm, said the company is manufacturing polyethylene collapsible tubes and "squeeze-to-use" bottles at a rate of about half a million per week and plans to quadruple that figure in a year. The containers are marketed under the trade name "Bracon." The tubes cost about 10% less than conventional metal tubes. Bottles are less expensive than previous plastic types.

◆ ◆ ◆

A **humidity cabinet** for laboratory testing and research has been announced by the Crest Mfg. Co., 66 Potrero Ave., San Francisco. The Crest Humidity Cabinet is a completely self-contained unit with extremely accurate humidity and temperature control in ranges to 95% R.H. and temperatures to 120° F. A descriptive bulletin is available from the company.

(Continued on page 34)

Spice Shipments are not always the same...



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Cake Icings
Canned Fruit
Cheese Spreads
Chocolate Milk
Chocolate Syrups
Confectionery
Dehydrated Soups
Dessert Mixes
Flavoring Emulsions
French Dressing
Frozen Fish
Frozen Fresh Fruit
Frozen Fruit Juices
Fruit Fillings (Pie)
Fruit Juices
Fruit Pie Fillings
(canned, ready-to-serve)
Gas Whipped Cream
Ice Cream Stabilizers
Marshmallow Toppings
Meringues
Milk Puddings
Pie Fillings (Dry)
Pumpkin Pie Filling
Ripple Ice Cream Syrup
Sauces (Prepared)
Sherbet Stabilizers
Soups
Syrups
Water Gel Desserts

. . AND YOUR IMPROVEMENT PROBLEM HERE?

- ☐ Binding
- ☐ Bodying
- ☐ Emulsifying
- ☐ Gelling
- ☐ Modifying
- ☐ Stabilizing
- ☐ Suspending
- ☐ Thickening
- ☐ Custardizing milk & products containing milk solids
- ☐ Improving mouth-feel and flavor
- ☐ Increasing efficiency of component ingredients
- ☐ Modifying ice crystal growth
- ☐ Physical & anti-oxidant protection
- ☐ Thermally-reversible gels

THEN YOU'LL FIND YOUR ANSWER HERE!

*SeaKem is the trademark for the standardized, water-soluble, sea plant extractives manufactured by the Seaplant Chemical Corporation. Refined by rigidly controlled processes which insure dependable uniformity and purity, SeaKem "Colloids Out of the Sea" are light amber to colorless, free-flowing flaky powders. Available in a variety of types suitable for use in an unusually wide range of food applications (see lists above), SeaKem Products have won acceptance on the basis of proven advantages with leading manufacturers and processors.

Are your food product and improvement problem listed above? Then follow the lead of top food manufacturers and try SeaKem "Colloids Out of the Sea".* Discover how SeaKem Products can help improve *your* food product . . . make it better . . . easier to sell.

Whether your problem is an old story or "different from anyone else's", chances are SeaKem "Colloids Out of the Sea" and Seaplant Chemical's confidential laboratory service, can mean time and money to you. Fill out and mail coupon today for prompt attention.

CLIP AND MAIL FOR LATEST SEAKEM TECHNICAL BULLETINS

NAME ..... TITLE .....

COMPANY .....

STREET .....

CITY ..... ZONE ..... STATE .....

Type product and problem .....

Check here if you desire samples as well as technical bulletins ☐

Serving industry with "Colloids Out of the Sea"

SEAPLANT CHEMICAL CORPORATION
63 David St., New Bedford, Massachusetts

FOOD INDUSTRY TOPICS

(Continued from page 32)

Exceptional impact resistance and toughness is claimed for a new **corrosion-resistant, rigid plastic pipe** by American Hard Rubber Co., 93 Worth St., New York 13, N. Y. Called Dur-Ace it is a general-purpose material capable of handling most common corrosives, with a favorable cost factor. The product is light in weight, odorless, tasteless, non-contaminating, resistant to all inorganic acids and alkalis with exception of a few strong acids, and has limited resistance to organic solvents. Its operating efficiency extends over a temperature range of from minus 40° F. to 170° F.

◆ ◆ ◆

A portable electronic testing system that permits engineers to estimate the effect of the addition of new equipment to an industrial operation without actually test-installing such equipment was unveiled recently by the Minneapolis-Honeywell Regulator Company's Industrial Division, Wayne & Windrim Aves., Philadelphia. The new system, known as a servo analyzer, automatically translates behavior characteristics of equipment to a chart record. This, in turn, is analyzed to determine how such a component will affect the over-all behavior of the operation. The system reportedly can save 30-60% of the research time involved in re-designing a process.

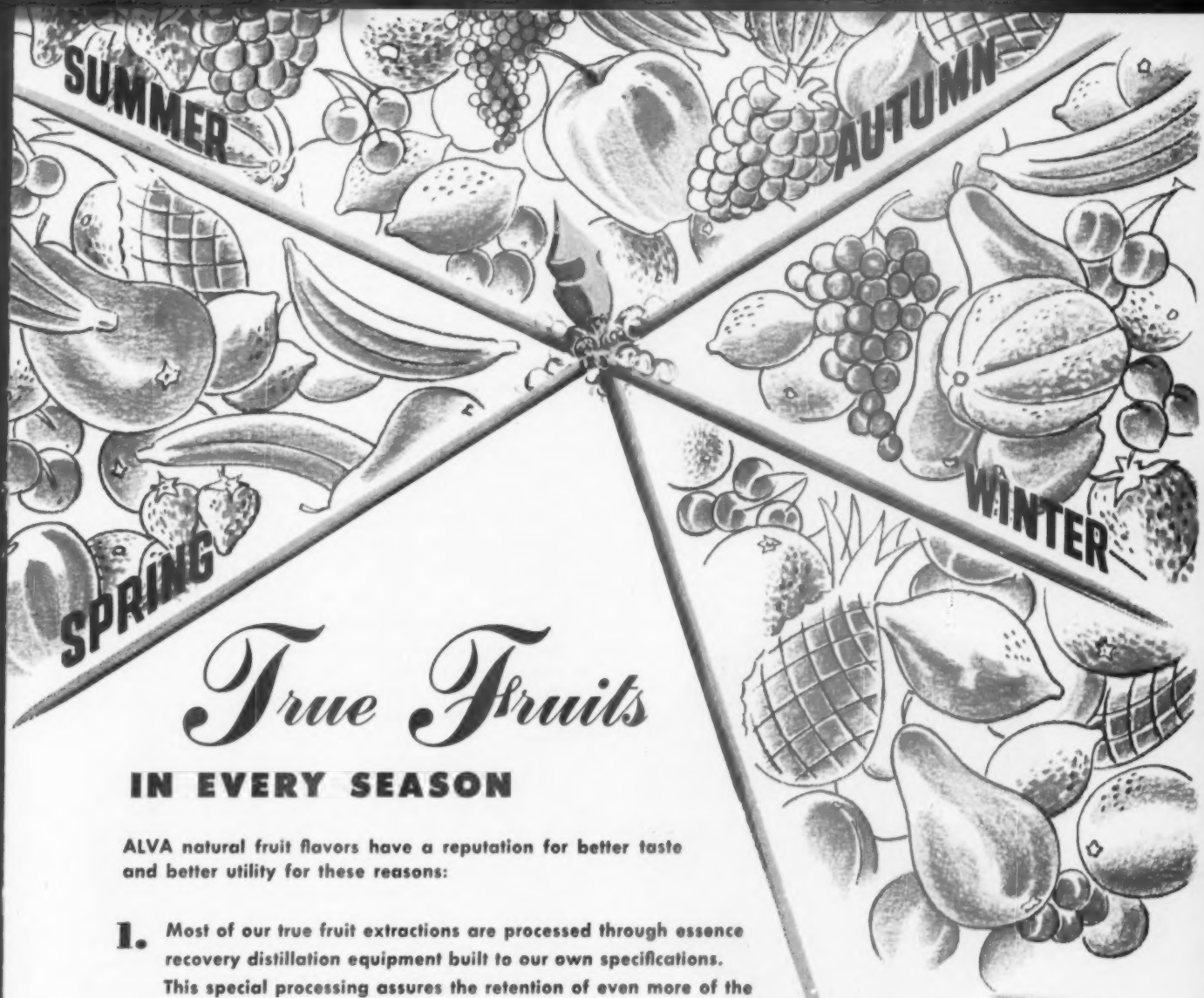
◆ ◆ ◆

Titeflex, Inc. of Springfield, Mass., announces it is now in production on a complete line of its **quick-seal, leak-proof hose couplings** with built-in single or double check valves. The Titeflex quick-seal hose coupling is particularly suited for high-pressure, heavy-flow applications because of a simple construction which makes the hose line leak-proof the moment the coupling is closed, and seals it tighter the higher the pressure builds up inside. In addition, this construction provides a full-swiveling feature that prevents hose kinking, thus assuring long hose life and permitting rapid hose attachment. The built-in check valve arrangement eliminates the need to shut down pumps or close valves in order to break the connection, avoids loss of valuable or hazardous fluids when the line is opened, and eliminates need to drain lines prior to uncoupling.

◆ ◆ ◆

To meet the need for a test filter unaffected by corrosive liquids, the Hercules Filter Corp., Paterson, N. J., has produced an **all-plastic filter,** available with leaves made of three different plastic materials—acrylic, glass-reinforced polyester, and polyvinol chloride. The plastic filter, a replica of the large Hercules pressure leaf filter, makes it possible for manufacturers not only to determine the performance of the filter for the operation they are testing, but also enables them to determine the reaction of three different types of plastics to the corrosive action of their materials. This test filter, of one-half foot capacity,

(Continued on page 36)



True Fruits

IN EVERY SEASON

ALVA natural fruit flavors have a reputation for better taste and better utility for these reasons:

1. **Most of our true fruit extractions are processed through essence recovery distillation equipment built to our own specifications. This special processing assures the retention of even more of the light fugitive esters so difficult to hold in normal extraction procedures.**

2. **Storage facilities are maintained under ideal control conditions, improving the life of flavors and guaranteeing freshness in each delivery.**

3. **Through the years ALVA has developed procedures for handling fresh fruit which assure 100% purity.**

ALVA true fruit flavors are ideal for every use, and the ALVA laboratories are eager to help with recommendations and samples for every true fruit problem.

VAN AMERINGEN-HAEBLER, INC.

521 WEST 57th STREET, NEW YORK 19, N. Y.

Alva FLAVORS

dry flavors
"FLAV-O-LOK"
A highly suitable line of dry flavors for use in DRY-MIXES, such as Gelatin desserts, pudding powders, beverage powders sherbet mixes, pie-filling powders, etc.

polak's frutal works
middletown, new york
Branch Office: Chicago, Illinois
800 North Clark Street

Available Flavors

Lemon	Apricot	Cola
Lime	Banana	Aniseed
Orange	Currant	Spearmint
Tangerine	Grape	Peppermint
Raspberry	Pineapple	Sassafras
Strawberry	Methyl Salicylate	

Superb in taste and Keeping properties

FOOD INDUSTRY TOPICS

(Continued from page 34)

may be used with liquids up to 150° F. in temperature, except in the case of the polyester model where top temperature is 300° F. The manufacturer will arrange for tests of this filter upon request.

◆ ◆ ◆

A new Belmont **meter-indicating level monitor** deriving its signal from an inert capacitive-type sensing probe is recommended for application with most nonadhesive chemicals, milk, oils, refrigerants such as ammonia and the Freons, and all condensed gases over a temperature range from 500° F. to minus 425° F. The instrument can be operated from high vacuum to pressures as high as 100,000 psi, and the repeat meter can be located at a practically unlimited distance from the main sensing installation. Write for leaflet Form LI-2 to Thermo Instruments Co., 1310 Old County Rd., Belmont, Calif.

◆ ◆ ◆

A new temperature transmitter and a new magnetic flow meter have been developed by The Foxboro Company, Foxboro, Mass. The Model 12A Temperature Transmitter is a nonindicating device of the "force balance" type which accurately measures process temperatures and pneumatically transmits the information to a central recording or controlling station. It has a calibrated accuracy of ½% of the temperature span and compensated for ambient temperature and barometric pressure variations. The flow meter, designed for 2" to 8" flow lines, incorporates all the unique advantages of electromagnetic metering, and is additionally rated for unlimited maximum flows, making practical a number of flow measurement applications impossible with ordinary metering equipment. Unaffected by the pressure, viscosity, density, or changes in conductivity of the flowing liquid, the meter is recommended for aqueous solutions, slurries, acids, and other corrosives, in addition to food and drug products requiring sanitary processing. Complete specifications of the latter instrument are available in technical report TI 27-A-71a.

Model 12A with stainless steel capillary and bulb

Foxboro also announces issuance of a 24-page Bulletin 6-10, "Pressure Recorders," which fully explains the firm's line of pressure instruments designed for direct measurement, remote transmission, and automatic control.

◆ ◆ ◆

Central Scientific Co., 1700 Irving Pk. Rd., Chicago, is now marketing a **new Waring Blendor of one-gallon capacity** to users in the educational, industrial, and medical laboratory fields. Developed to save time and work in larger mixing operations, the new model is the first high-speed blending device of this kind capable of holding more than 37 ounces. Automatically

(Continued on page 38)

ANSWER TO LEAVENING PROBLEMS Family Style

A FAMILY OF FOUR PROVED MONSANTO PRODUCTS ARE READY TO MEET YOUR LEAVENING NEEDS:

Monsanto SAPP-40 . . . ideal for machine doughnut mixes. Gives a fine texture and crust. Reduces tunnels. Cuts down on grease absorption, improves doughnut's shape. Here is a product that gives uniform action—every time.

Monsanto SAPP-28 . . . a slow-action baking acid, especially suited for cakes, biscuits, muffins. Has beneficial effect on gluten in flour; imparts greater extensibility and higher gas retention.

Monsanto HT Phosphate (MCP Monohydrate) . . . versatile, effective, contains no free phosphoric acid, hence does not attract moisture and cause premature reaction with soda. Use it alone or in combination with other Monsanto leavening agents for good results.

Monsanto PY-RAN (MCP Anhydrous) . . . for stability never before possible in self-rising flour and cake mixes. PY-RAN gives a slow, controlled gas release during first two minutes of the mixing of the dough or batter. Tests clearly prove PY-RAN releases CO_2 slowly during first two minutes of the mixing of the dough or batter. This two-minute reading is especially important, as any CO_2 evolved during this time will be unavailable for leavening action in the oven.

For more information or a copy of the new booklet, "Monsanto Phosphate Leavening Agents," write to MONSANTO CHEMICAL COMPANY, Inorganic Chemicals Division, 1700 South Second Street, St. Louis 4, Missouri.

PY-RAN: *Reg. U. S. Pat. Off.*

MONSANTO

SERVING INDUSTRY...WHICH SERVES MANKIND

sweet'en-er

That which sweetens or imparts a sugarlike flavor

Example: GLYCERINE!

In products like cough drops, toothpastes, candies, capsules, and medicines, where Glycerine's major properties make it an important ingredient, Glycerine's pleasant taste is an extra "plus." Glycerine not only acts as a humectant, demulcent, solvent, plasticizer or preservative in formulations of this type, but also enhances their flavor.

U.S.P. Glycerine is nontoxic and easily digested. Its applications in food processing have been accepted by the American Medical Association Council on Foods, and permitted by Federal and State food and drug authorities.

If you're developing a product that must have any of the properties mentioned—and be palatable too—check Glycerine.

New Pectin Jelly

For example, a concentrated pectin jelly composition was recently patented. When dissolved in hot water and then cooled, this solid aqueous gel forms a larger volume of edible jelly dessert. Glycerine acts as a sweetener.

Balance of Properties

Glycerine's sweetening action is only one part of the story. You can count on *versatile* Glycerine to serve as—

preservative	**bodying agent**
bacteriostatic	**stabilizer**
lubricant	**antifreeze**
penetrant	**blending agent**

Booklets on the application of Glycerine in the drug and cosmetic and food fields are available. For your copy, write Glycerine Producers' Association, 295 Madison Avenue, New York 17, N. Y.

Nothing takes the place of Glycerine

FOOD INDUSTRY TOPICS

(Continued from page 36)

controlled, it has five speeds ranging from 8,000 to 16,000 rpms. Price is $275. For further information write for descriptive circular 1240.

◆ ◆ ◆

The Henszey Co. of Watertown, Wis., manufacturers of dairy equipment and power plant specialties, announce introduction of a **new type spray dryer** for powdered milk and other food products. The dryer features "horizontal air suspension," a method of keeping the powder suspended in air instead of allowing it to drop to the floor of the drying chamber. This unique feature, combined with a single nozzle and low feed pressure, is designed to meet the increasing demand for high dispersibility and ease of reconstituting. The Henszey dryer can produce a very large particle of uniform size to meet this demand. For further information, write Mr. R. H. Baum, sales manager, at the above address.

. . . the literary corner

The benefits of the new tax law to research programs are succinctly reviewed in a short article in the September issue of *What's New in Food and Drug Research*, issued by Food Research Laboratories, Inc., 48-14 Thirty-third St., Long Island City 1, N. Y. Whereas the previous law permitted large organizations with regular research budgets to deduct research and testing expenditures on a current basis, under the new law all companies, regardless of the amount or frequency of their research appropriations, are allowed the option of deducting such expenditures currently or of capitalizing them for write-off over a period of not less than five years. Another pertinent aspect of the law concerns a new method for computing depreciation which offers greater latitude in selection of methods of depreciation for more rapid tax write-off—an important item in the research budget.

◆ ◆ ◆

Richardson Scale Co., Clifton, N. J., offers a new four-page technical reference on a recently developed servomechanism system. Components are a synchromechanism, control transformer (balancing synchro), servo amplifier, and servo motor. Besides describing construction features and listing the operating characteristics of the system, the reference includes photographs and engineering drawings of key parts and a diagrammatic layout showing how parts are hooked up. Information is also included on how remote recorders and tape printers may be hooked up and synchronized with servo units. For copies of Technical Reference 54B, write to Mr. Richard Steensma at the above address.

◆ ◆ ◆

A four-page illustrated bulletin on automatic regulators designed for use in the heating, power generating, and industrial processing fields has been made

(Continued on page 40)

For Vitamin A–Look to Merck

Large capacity of this new Merck Plant assures an uninterrupted supply of Vitamin A

Merck leadership in vitamin manufacturing assures quality Vitamin A for the food industry.

Merck offers Vitamin A Acetate in vegetable oil, a light-colored product, free from off tastes, eminently suited for use in margarine and other foods. Supplied in batch-size or bulk containers, 200,000 and 400,000 units per gram. For information on other potencies, write to the address below.

Merck's experience of almost two decades in the manufacture of vitamins is offered to help you in the application of Vitamin A to your processes.

Vitamin A, Merck

Research and Production
for the Nation's Health

MERCK & CO., INC.
Manufacturing Chemists
RAHWAY, NEW JERSEY
In Canada: MERCK & CO. Limited – Montreal

FOOD INDUSTRY TOPICS

(Continued from page 38)

available by Atlas Valve Co., 280 South St., Newark, N. J. Eleven automatic regulating devices are described; among them precision high and low pressure reducing valves, relief and lever-operated control valves, temperature regulators, standard and excess pressure pump governors, a super-sensitive pressure regulator, and an air-actuated pilot.

◆ ◆ ◆

A new catalog on blending, processing, and heat exchange equipment for the chemical and processing industries has been issued by the Patterson-Kelley Co., Inc., East Stroudsburg, Pa. Bulletin 13 covers a variety of sizes and adaptations of P-K's three basic types of blendors. Also available from the same firm is a beautiful 48-page color catalog (Catalog No. 18) on P-K "Hot Water Storage Heaters."

◆ ◆ ◆

The USDA has made available *Proceedings* of the "Third Conference on Processing as Related to Nutritive Value of Cottonseed Meal," compiled by members of the Southern Utilization Research Branch. This Conference—sponsored jointly by the Southern Regional Research Laboratory of SURB and the Natl. Cottonseed Products Assn.—met in November 1953 to report progress in a broad program of cooperative research underway since 1948. *Proceedings* include information on background and aims and on current nutritional investigations. Addresses delivered at the eight seminars of the Conference are abstracted. A copy may be obtained by writing the Southern Regional Research Laboratory, 2100 Robert E. Lee Blvd., New Orleans, La.

◆ ◆ ◆

MMM, Inc., 7120 Ave. C, Houston, Texas, has issued a four-page brochure on its low-temperature pipe insulation, Vapo-Wall (made of Dow Styrofoam), providing a complete picture of Vapo-Wall's insulating properties plus helpful recommendations on how to order and apply this pipe covering. Booklets are accompanied by price charts, detailed specifications, and other data.

◆ ◆ ◆

The August issue of *Canada's Health & Welfare*, published by Information Services Division, Dept. of Natl. Health and Welfare, Ottawa, contains a good review of a book which might hold interest for a considerable number of American processors. The book —*Canada's Food and Drug Laws*—was authored by Mr. Robert E. Curran of the Health & Welfare Department. Published by Commerce Clearing House, Inc., Chicago, 1953, it runs 1,138 pages and sells in this country for $19.50.

◆ ◆ ◆

New 80-page General Catalog 79 has just been issued by Koch Supplies Inc., 2520 Holmes St., Kansas City 8, Mo. Containing more than 500 illustrations, it gives complete information, specifications and prices on equipment and supplies used in slaughtering, meat smoking, lard rendering, meat processing, sausage making, locker plants, poultry houses, restaurants, and institutions. For a free copy write to Dept. 26 at the above address.

◆ ◆ ◆

The diversified manufacturing activities of the Blaw-Knox Co., Pittsburgh, are shown in a recently published 50-page informational brochure entitled "This is Blaw-Knox." Of particular interest to readers of *Food Technology* is the section devoted to the firm's Buflovak Equipment Division which designs and builds equipment for processing chemicals, pharmaceuticals, dairy and food products, and byproduct recovery. For a copy write: Blaw-Knox Co., Farmers Bank Bldg., Pittsburgh 30, Pa.

◆ ◆ ◆

Among interesting references contained in the September issue of *Fatty Acid News Digest*, published by Fatty Acid Division, Assn. of American Soap & Glycerine Producers, Inc., 295 Madison Ave., New York 17, N. Y., is one on a patented "hard butter process"

(Continued on page 46)

FOOD RESEARCH

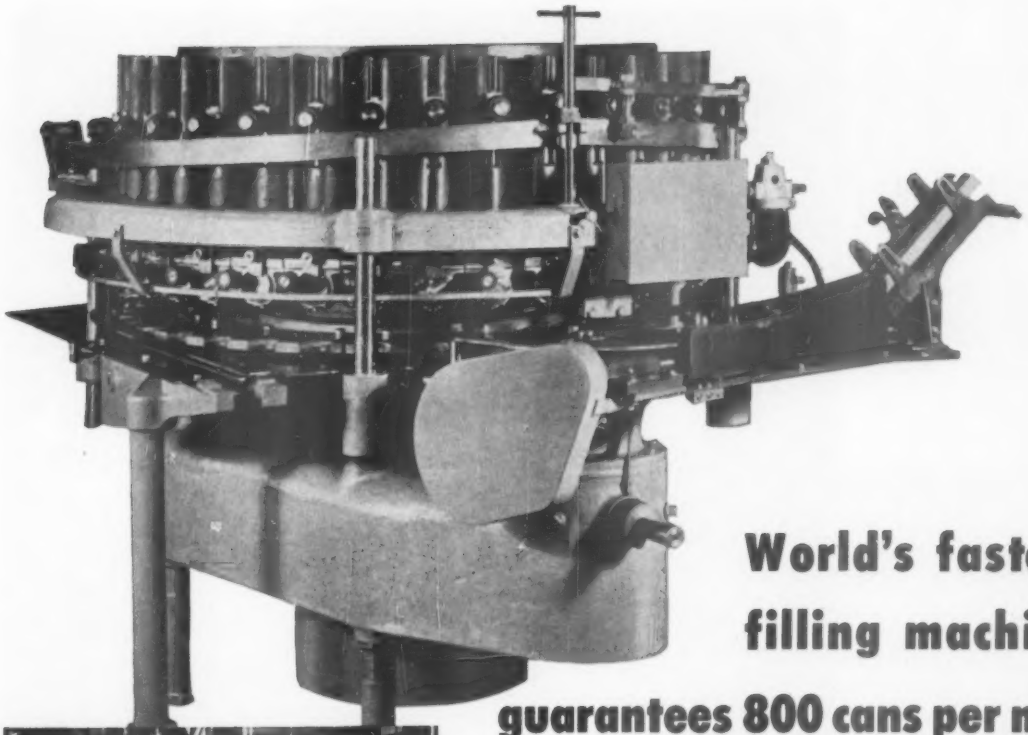
Enters Twentieth Year

Food Research, companion journal to Food Technology, will complete in 1955 two decades of publication. Since its founding ***Food Research*** has published the results of advanced studies in the fields of nutrition, food chemistry and engineering, bacteriology, the sensory evaluation of foods and in numerous subfields within these broad categories.

Recently, in connection with an exhaustive search of food literature that he was making, a distinguished veteran of food research went through all extant issues of ***Food Research***. At the end of his long labor, he had one simple comment: "It is quite a journal—the most impressive in terms of coverage, authorship, and consistent quality that I have ever examined."

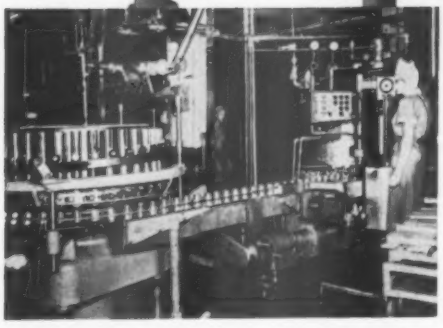
Ample evidence of this "consistent quality" will be found in the January-February issue of ***Food Research***. For example, this first issue of the new year will contain an article describing a method for preparing and using color references for stored, processed food—in this instance dehydrated sweet potatoes. One reviewer enthusiastically called this article "food research at its best." Another article in this forthcoming issue surveys the newer concepts of the role of fats and the essential fatty acids in the diet. This article was acclaimed the winner against a field of nearly 200 papers of the prized Monsanto Award.

Does your technical library subscribe to ***Food Research?*** If not, it is suggested that ***Food Research*** is "capital equipment" in the field of scientific power. Subscriptions can be placed immediately with the Institute of Food Technologists, 176 West Adams St., Chicago, Illinois.



World's fastest filling machine guarantees 800 cans per minute

New Pfaudler 35 Station Piston Filler!



More than 800 cans of baby food a minute are filled at H. J. Heinz Co., Leamington, Ontario, with this new Pfaudler 35 station filler. Filler, world's fastest, was developed at Heinz's request by The Pfaudler Co. with cooperation of Continental Can Co.

On a single machine, you can fill a container of your product for every man, woman and child in a city the size of Riverside, California (population 46,764)—in less than 1 hour!

That gives you some idea of the production advantages of the new Pfaudler 35 piston filler. It's the world's fastest. We *guarantee* it will fill 800 cans per minute, in all sizes up to 16 oz. And we've seen it go higher than 1000!

Breath-taking production speeds on the new Pfaudler 35 are easily regulated with these special features:

Magnetic brake stops the filler within .2 second after you apply it, and is synchronized with a similar high-speed brake on the closing machine.

Electrically controlled no-can-no-fill mechanism is activated pneumatically for split-second spill prevention.

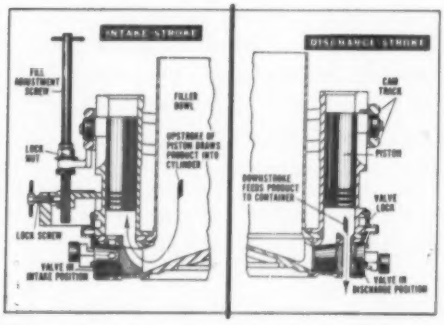
Adjustable tilt—Cans ride on a track which tilts them for filling. Angle of tilt adjusts to speed of filling and product.

Precise filling—In most cases, we can guarantee an accurate fill within ±1/10 oz.

Maintenance of the machine is simple. You have only 3 points on the entire filler to lubricate by hand. Bearings in the base and all gears are automatically lubricated. Cleaning is also easy, because only the valves and pistons need be removed, and you don't need any tools to do the job.

Challenge us

Make us prove to you that the Pfaudler 35 will actually pay for itself in lower production costs, higher production. Mail the coupon below for full details.



Filling action is illustrated above. The diagrams show position of operating parts on opposite sides of the machine.

THE PFAUDLER CO., Dept. FT-12, Rochester, N. Y.
Tell me more about your "Pfaudler 35" piston filler.

Name_____

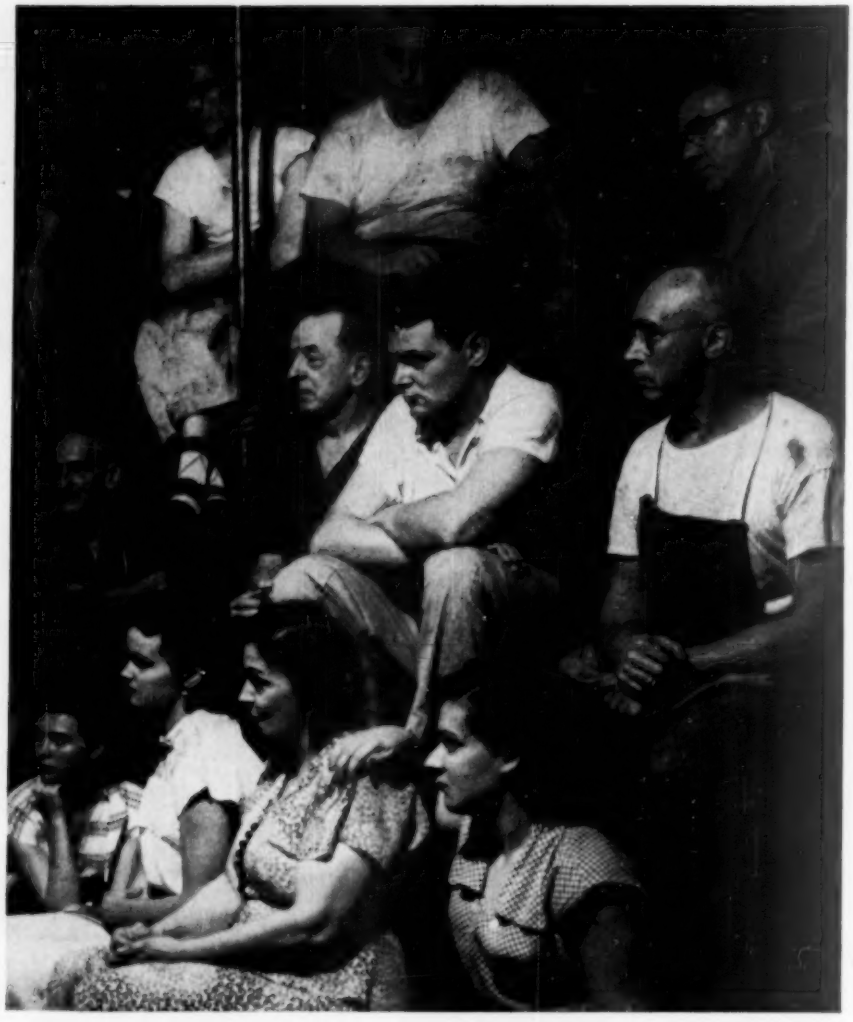
Title_____

Company_____

Address_____

City_____ Zone____ State____

THE PFAUDLER CO., ROCHESTER 3, N.Y.



the facts of life

about cancer

The facts of death from cancer are all too familiar. Too many have known the tragedy of losing a family member... a friend... a fellow worker. Too few know the facts of life about cancer. Yet they are there for the asking... or the seeing... or the listening. The American Cancer Society teaches life-saving facts about cancer every day of the year. Through films... pamphlets... exhibits... window displays... via radio... television... newspapers... magazines... from lecturers... information centers... you can learn vital facts that might one day mean the difference between life and death.

The American Cancer Society maintains the first line of defense in the battle against man's cruelest enemy. Teaching you how to protect yourself and your loved ones from death by cancer, supporting research in more than 100 medical and scientific centers, keeping your doctor informed of new techniques of diagnosis and treatment are but a few of the Society's many functions, all of them directed to the ultimate conquest of the disease.

Don't turn away from the facts about cancer. They can be the facts of life for you and your family. Visit the American Cancer Society office nearest you, or write to "Cancer" in care of your local Post Office.

American Cancer Society

Foods move faster from counter to table

when MSG* is on the label

Payoff on processed food sales comes when shoppers reach for one brand instead of another. Make sure it's yours by using Huron MSG.

Frozen foods — chicken pies, fish, meat, poultry, and vegetables — retain their pre-freezing flavor longer when you use Huron MSG. In many cases it also helps preserve their original color.

Canned foods — soups, gravies, hash, beans and others — keep their original flavor through all three cookings (yours plus the housewife's) with Huron MSG (made *only* from wheat protein).

Small fry make a big difference in selling food.

In the shoppers' home, your product has nothing more or less than its own flavor to stand or fall on. If it passes this critical taste test, it rates a permanent place on the family shopping list.

That's why so many processors "insure" taste appeal with Huron MSG — America's first MSG and still the quality standard. You can be next!

For suggestions and sample, write Huron's Technical Service Department, HURON MILLING CO., 9 Park Place, New York 7, N.Y.

* Huron MSG, of course!

B.4.2

Huron MSG

PURE MONOSODIUM GLUTAMATE 99+%

Made by the American pioneers in protein derivatives

SALES OFFICES: 161 E. Grand Avenue, Chicago 11 • 13 E. Eighth Street, Cincinnati 2 • 383 Brannan Street, San Francisco 7

FACTORIES: Harbor Beach, Michigan

"7,125 men and women signed up to join those already saving for their financial security..."

GEORGE H. COPPERS

President,
National Biscuit Company

"There is no greater honor than partnership in an enterprise as important to a nation as the Payroll Savings Plan for United States Savings Bonds. We view our recent person-to-person canvass of employees in behalf of Bonds as practical patriotism. It supports our Government's efforts to stabilize the value of the dollar. The campaign also benefited our employees. 7,125 men and women signed up to join those already saving for their financial security in this easy, automatic way."

The Payroll Savings Plan is the backbone of Series E Bond Sales. 8,500,000 employees in more than 45,000 companies invest more than $160,000,000 in Savings Bonds *every* month.

The person-to-person canvass is the keystone of The Payroll Savings Plan. In company after company person-to-person canvasses *conducted* by *employees* have increased participation to 60%, 70%—even 90% plus.

Why don't *you* conduct a person-to-person canvass in *your* company? Here are two, simple steps:

- Tell the Savings Bond Division, U.S. Treasury Department, Washington, D.C., you want to conduct a person-to-person canvass, they will show you how easy it is to install the plan.
- Over *your* signature tell your men and women you are 100% behind the Payroll Savings Plan because it enables them to build personal security . . . it is a check on inflation and helps to stabilize the dollar . . . it has set up a reservoir of reserve purchasing power—over $37.5 billion—the cash value of Savings Bonds held by individuals at the end of July, 1954. The greatest reserve of purchasing power this or any other country has ever had.

Your phone call, telegram or letter to Savings Bond Division, U.S. Treasury Department, Washington 25, D.C., will bring prompt co-operation from your State Savings Bond Director. Act today.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

THE INSTITUTE OF FOOD TECHNOLOGISTS

Celite Filtration provides:

Brilliant polish—at fastest flow rates

QUALITY THAT SPEEDS SALES, by a filtration method that speeds production . . . this double advantage is yours with Celite* diatomite filtration.

You obtain brilliant polish, because Celite removes even the finest suspended impurities. Yet you secure the fastest flow rates consistent with desired quality, because a Celite filter cake contains millions of microscopic filter channels per sq. ft. of surface. For example, with a typical syrup, you can achieve excellent clarity at a flow rate of 10 gal/sq ft/hr—using a standard grade of Celite!

Production men also favor the Celite method because of its simplicity. It may be used with any type of conventional filter unit, and it is almost automatic in operation. For maintenance work too, Celite Filtration is the economical, efficient way to obtain pure process water for bottle washing, equipment cleaning and other service functions.

Because of its many advantages Celite Filtration is used by most sugar refiners and brewers, by leading bottlers of soft drinks, processors of fruit juices, cooking oils, fats . . . and many other products.

How can Celite aid your product or process? A Johns-Manville Celite Filtration Engineer will gladly show you, without obligation. Simply write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville CELITE** FILTER AND PRESSING AIDS

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I-46

FOOD INDUSTRY TOPICS

(Continued from page 40)

—a process for esterifying coconut fatty acids with glycerine, producing a neutral glyceride ester which, upon hydrogenation, yields an improved "hard butter" for chocolate coatings, icings, and other edibles. (Assigned by Barsky and Zinzalian to E. F. Drew & Co.) Also a note that the Sugar Research Foundation has announced a new and practical process for making detergents and emulsifying agents from a combination of sugar and tallow. The complete write-up of the latter item appears in *Chemical Week*, Sept. 11, 1954.

. . . *building up and branching out*

The Atlas Powder Company's new esterification plant in Brantford, Ont., began production on October 7 according to Mr. F. E. Sterne, managing director of Atlas Powder Co., Canada, Ltd. The new plant is now producing Atmul 82, a mono- and di-glycerine food emulsifier used by the baking industry to improve the eating quality, the appetizing nature, and the attractiveness of bread and bread type rolls, sweet yeast goods, doughnuts, and all types of cakes. Capacity is sufficient, according to Mr. Sterne, to supply the emulsifier needs of the entire Canadian baking industry. The plant also has facilities to produce ester type emulsifiers used by the cosmetic, pharmaceutical, textile, insecticide, cleaning, and polishing industries, and in the mining and petroleum fields. In addition to supplying the above products under the Atlas name, the plant will also undertake production of custom-made emulsifiers for specific uses and for sale under the private label of industrial distributors.

. . . *the human element*

Promotion of **Mr. Thomas C. Garren** to the newly created position of assistant to the director of technical service has been announced by the A. E. Staley Mfg. Co., Decatur, Ill., corn and soybean processor. Technical service is a branch of the firm's research department and is headed by Mr. James P. Casey, director.

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Dr. Charles N. Kimball, president, Midwest Research Institute, Kansas City, Mo., made known the appointment of **Mr. Richard L. A. Sterba,** formerly on the staff of the University of Chicago, as associate economist. Mr. Sterba will play an important role in the study of engineering economics, a field in which the Midwest Research Institute has undertaken important studies recently.

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Miss Sally Foss has been appointed home economist at Henningsen Inc., Springfield, Mo. She will engage

(Continued on page 48)

EMPLOYMENT NOTICES

WANTED: Food Technologist Ph.D. or Biochemist Ph.D. with Home Economics experience. Well-known northwestern college has opening in teaching and research in foods. Salary commensurate with education and experience. Opportunities for advancement excellent. Will supply details on request. Send summary of education, experience and expected salary. REPLY BOX 363, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Flavor Chemist, experienced in preparation, research and development of flavors. Position includes technical supervision and quality control. Midwest location. REPLY BOX 362, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

CHEMISTS (2)
PACKAGING EXPERIENCE

Men, to age 35, B.S., knowledge testing adhesives, films, foils, waxed papers, paperboard, printing inks. 1 — Chemist to supervise 3 technicians checking specification packaging materials. Some administrative and contact work. 1—Chemist for independent research on packaging materials evaluation; shipping container and package testing. Leading food manufacturer, New York City area. State experience, education, salary expected, etc. REPLY BOX 361, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

FOOD TECHNOLOGIST

Graduate with organic, qualitative, quantitative and/or Bio-chemistry with understanding of physics, engineering, and statistics, no age limit, to work in lab developmental and research work and to apply results to actual production for progressive S. E. Mfgr. concern. Should know food processing, packaging, materials and problems concerning fats and oils. Salary open with good advancement opportunity. Send complete resumé of training experience and personal background with small photo to Personnel Manager, P. O. Box 4265, Atlanta 2, Georgia.

POSITION OPEN—MALE

FOOD TECHNOLOGIST for Technical Service and Sales Work. Broad experience in field of canning, freezing or meat packing required. Sales experience desired, sales inclination necessary. Location East, travel nation-wide. Expenses fully paid. Car provided.
Send complete details; state salary desired. Application held in strict confidence. Company's employees know of this ad. Company will assist relocation charges. REPLY BOX 364, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Technical Salesman. Well established organization in the essential oil and flavoring extract field seeks experienced man to cover specific Eastern states territory. Must have some technical knowledge. Give full details and background. REPLY BOX 370, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Graduate Food Technologists. Openings in quality control for recent graduate and for man having 4-5 years' experience in food industry. Nation-wide company provides complete employee benefit program, including liberal pension plan and profit sharing. Expansion program offers potential advancement into plant operations openings. Submit complete resumé. REPLY BOX 375, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

NATIONAL FOOD PROCESSOR, famous for quality, presents an opportunity for Food Technologist with experience or advanced degree. Responsible for administration of quality and bacterial control program. Midwest location. Submit educational and work experience resumé, salary requirements, and availability date. REPLY BOX 376, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Candy Technologist, experienced in fondant, butter-cream centers and coatings manufacture, for responsible research position. Work will be primarily on confectionery products allied to the baking industry. Location Chicago —old established firm. REPLY BOX 377, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Flavor Chemist. Midwestern city. Must have adequate training, plus minimum of 3 yrs. experience in compounding of flavoring materials. Starting salary based upon education and experience. Send resumé. Not replacement position but part of planned expansion program. REPLY BOX 374, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Food Technologist with advanced degree or experience equivalent. Must be capable of starting quality control and research laboratory for Mid-Western manufacturer of food products. Excellent opportunity for advancement. Salary open. REPLY BOX 373, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: OUTSTANDING CHEMICAL ENGINEERS for Research and Development in Broadly Diversified Food Industries. Salaries and opportunities attractive for high caliber men up to fifty years of age. Candidates should possess fine training, preferably through M.S. and/or Ph.D. levels in chemical engineering; also excellent proven competence, professional experience and leadership. Appreciation of the delicacies of aroma, flavor and color of biological food materials would be advantageous. Fine character, and splendid references in due course, are essential. Openings are available at several levels, depending on qualifications. Confidences respected. Write for personal data forms or send biographical sketch. REPLY BOX 372, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

WANTED: Food Technologist. Young man to train for management. Candy Plant. Technical or practical experience desirable. REPLY BOX 365, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Quality Control Supervisor. 8 yrs. production experience major distiller, made successful contributions in all quality control functions, proven administrative and problem-solving ability, 32, Harvard honor grad. Food or beverage industry. REPLY BOX 367, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Pickle man, M.S. Bacteriology, thoroughly experienced in managing pickle plant. Know practical and technical phases of pickle operation from green stock to finished product. Qualified to do quality control, spice formulation, and product development. Married, family man. REPLY BOX 368, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Oil Chemist. Ph.D. 2 yrs. post doctoral plus 4 yrs. post graduate research and teaching experience in the Chemistry of fats and oils. A number of publications. Desires permanent academic position for teaching and/or research. REPLY BOX 366, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Food Technologist, Ph.D. 29. Recent graduate with training in Food Technology, Chemistry, and Chemical Engineering, with experience in research and quality control. Desires position in this field. Will consider academic position. REPLY BOX 378, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Biochemist - Microbiologist - Food Technologist, Ph.D. 1951. Over 5 yrs. industrial research in fields basic to Food Technology, i.e., starch, proteins, carbohydrates, yeast fermentation, foams, gels, as well as brewing and baking. Available to progressive organization seeking new product research and development. Patents and publications. Group leader. REPLY BOX 371, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

AVAILABLE: Food Technologist. Desires responsible position as plant manager or product development and quality control. MIT. Experience in concentrates, canned foods, beverages, flavors. REPLY BOX 369, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

MAN'S FOODS

by Lloyd B. Jensen, Ph.D.

This book is the story of man's quest for food through the ages. It is at the same time a documented scientific work and a piece of fascinating reading. It covers a vast field of the history of many foods that have affected man's organic and social evolution. 288 pages, 6 x 9, $4.50.

THE GARRARD PRESS, Publishers
Champaign, Illinois

FOOD INDUSTRY TOPICS

(Continued from page 46)

in research work in both new and improved egg products and their uses, and will assist in the quality control of the company's products. A home economics graduate of Hood College, Frederick, Md., she completed the work for her master's degree at Iowa State College.

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Mr. Rogers

Mr. Hatton B. Rogers, formerly director of technical service for the Huron Milling Co., has joined Dodge & Olcott, Inc., as director of the Dry Solutions Division. Previous to his Huron position, Mr. Rogers had been with the Research Laboratories of the Natl. Canners Assn., the Army Subsistence Research Program, and the Phillips Packing Co. of Cambridge, Md.

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Mr. George H. McGlynn, vice president and treasurer of Magnus, Mabee & Reynard, Inc., essential oil firm, was appointed a member of the Executive Committee of the Drug, Chemical, and Allied Trades Section of the New York Board of Trade at a meeting of the Section held at Pocono Manor, Mt. Pocono, Pa., in September. **Mr. Joseph Baird Magnus,** also an MM&R vice president, is vice chairman of the International Trade Section of the New York Board of Trade.

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Mr. Joseph H. Kennan, professor of mechanical engineering at Massachusetts Institute of Technology, has been named to receive the Worcester Reed Warner Medal. The award, administered by the Board of Honors of The American Society of Mechanical Engineers, is conferred for an outstanding contribution to permanent engineering literature dealing with progressive ideas in mechanical engineering or efficiency in management. Mr. Keenan's book, *Thermodynamics*, first published in 1941, was adjudged by the Board as "a treatise of permanent value to the engineering profession."

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Appointment of **Mr. S. J. Stowell** as sales manager for Tranter Mfg. Co., Inc., Lansing, Mich., has been announced by Mr. James R. Tranter, president. The concern manufactures Kold-Hold and Kold-Trux refrigeration equipment and Platecoil heat transfer units for industry.

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"CANCER, I know, is a tougher problem. But the laboratories can lick that one, too—with our support. Already, they're curing people who would have been done for a few years ago. Last year—thanks to $5,000,000 allocated by the American Cancer Society from our contributions—they found out a lot more . . . though there's still a long way to go.
"THEY NEED MONEY, though. $5,000,000 is still less than 4 cents per American *per year*. Not enough to find the answer *fast* enough—230,000 Americans are going to die of cancer *this year*, they say.
"I'M NOT RICH, but I gave 'em $50 last year—hope to do better this time. After all, where would *I* be if the laboratories working on diabetes, that time, hadn't been given enough support—?"
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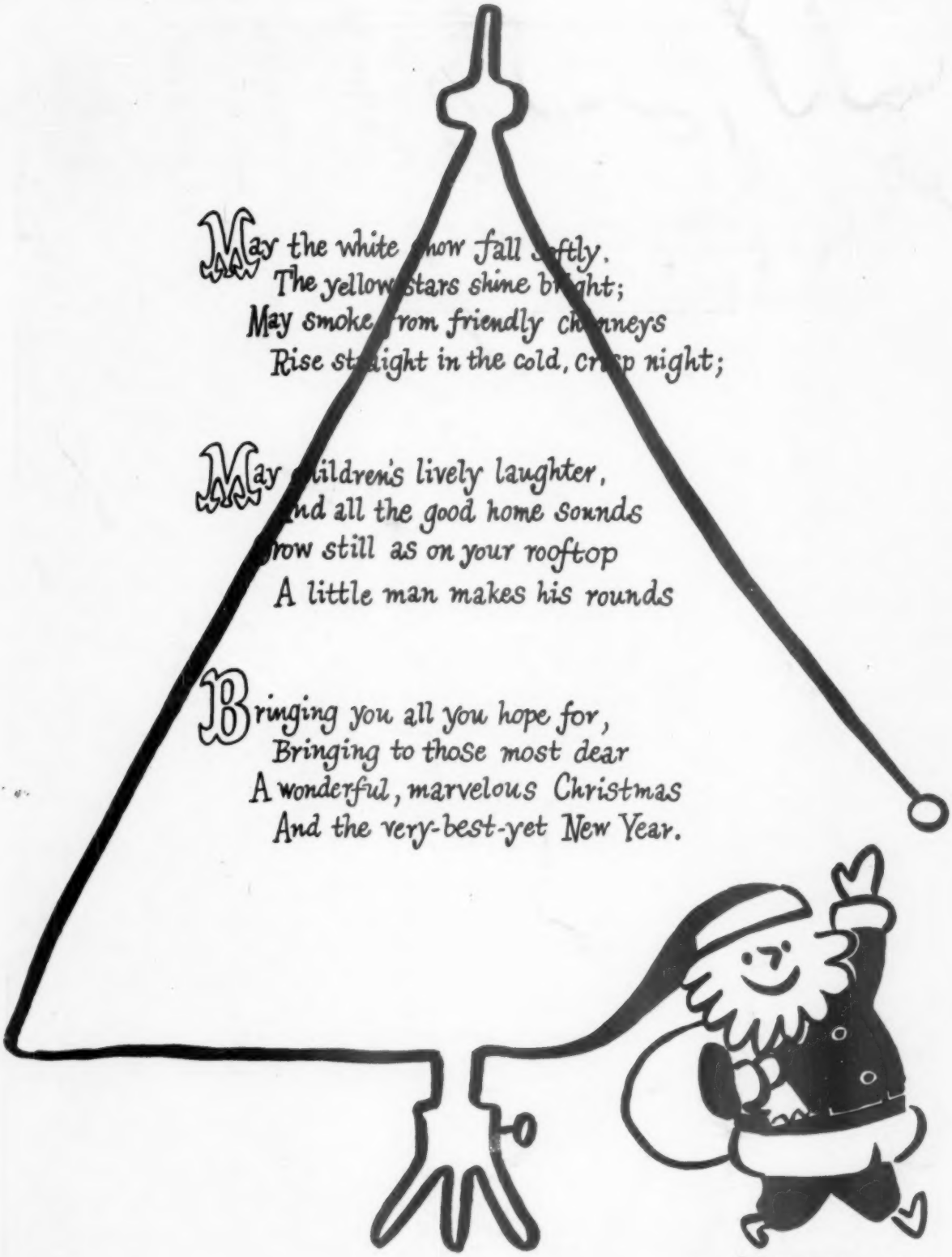
The yellow stars shine bright;
May smoke from friendly chimneys
Rise straight in the cold, crisp night;

May children's lively laughter,
And all the good home sounds
Grow still as on your rooftop
A little man makes his rounds

Bringing you all you hope for,
Bringing to those most dear
A wonderful, marvelous Christmas
And the very-best-yet New Year.



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